

5.2 INDICATOR CONTAMINANTS IN BEDDED SEDIMENT

This section summarizes the surface and subsurface sediment data collected in the upriver reach, downtown reach, Study Area reach, and downriver reach. The locations of all surface and subsurface sediment samples in the RI data set are shown on Maps 2.2-15, 2.1-17, H2.3-1 and H2.3-2. The discussion of each contaminant focuses primarily on the following items:

- A description of the data set for each contaminant, including sample counts, concentration range, and frequency of detection.
- A discussion of the surface and subsurface concentration distributions in the upriver reach, downtown reach, RI Study Area reach, and downriver reach. The RI Study Area reach is organized by eastern nearshore, western nearshore, and navigation channel subareas (Map 5.2-3335) and discusses distributions within river mile reaches and hydrodynamic reaches (see discussion in Section 3).
- A discussion of the vertical trends in sediment concentrations and the relationship of subsurface sediment to surface sediment concentrations.

The sediment chemistry distributions are depicted in three graphical formats:

1. Surface plan-view concentration maps and subsurface core concentration maps (all reaches)
2. Scatter-plot graphs of surface and subsurface sediment (RM 0.8-12.2)
3. Histograms comparing mean surface and subsurface concentrations by river mile (RM 0-11.8)

Core plots showing a higher level of detail have been produced for the following indicator contaminants:

- Total PCBs
- Total DDx
- TCDD TEQ
- Total PAHs.

Additionally, more detailed core plots were developed for total cPAHs and presented in Appendix D1.2. More detailed core plot maps were developed for these particular five contaminants because they are more prevalent throughout the Study Area and based on preliminary their relative contribution to risk in the baseline risk evaluations (Appendices F and G).



Commented [A1]: These were moved to Appendix A...need to update with current figure numbers.


Commented [A2]: Appendix D1.2 maps will replace subsurface maps for Total PCBs, Total DDx, TCDD TEQ, Total PAHs, and Total cPAHs. Appendix H3 subsurface maps for each indicator contaminant will be added to end of each series of subsurface maps in Section 5 as "n" and "o".

Commented [A3]: A histogram comparing the average surface sediment concentration to the average subsurface sediment concentration by RM will be presented for each indicator contaminant.

Commented [Int4]: These were not selected for detailed mapping because of preliminary findings of the risk assessments.

Commented [KK5R4]: Agreed. Language modified as discussed in meeting 7/25.

Surface Chemistry Maps: The plan-view concentration maps present all surface sample data using color-coded dots that correspond to a concentration scale for that particular chemical. The concentration ranges (or intervals) used in color-coding the chemical data shown on the maps were based on the frequency distributions (i.e., natural breaks), or as negotiated between EPA and LWG, in the data set for these contaminants and have no environmental significance. Non-detected concentrations are differentiated from detected concentrations on the surface maps by a dot in the center of the sample symbol . The maps include data points from locations that were dredged or capped subsequent to the collection of the sample(s) shown by a circle centered around the sample symbol ^{1,2}. Data from these areas are presented to show spatial patterns of chemicals from a historical, pre-dredge perspective. In addition, the surface maps include histograms showing the distributions and frequencies of the detected and non-detected results. Data from all samples shown on the maps are included in the histograms.

Subsurface Core Maps: The core maps show the distribution of contaminants with depth at each of the subsurface sediment sampling stations (these maps also include the surface sample data). Inset maps for densely sampled core areas are provided in most cases. In these maps, the actual core station is marked with a triangle . The core segment divisions displayed on the maps are scaled to the thickness of each sample interval. Note that these maps do include cores from locations that were subsequently dredged or capped, as indicated on the maps. Cores taken post-dredging are also included on the maps. The subsurface concentration maps do not indicate samples where concentrations are based on partial sums (i.e., A-qualified data; the few cases where data are based on partial sums from non-LWG studies).

Scatter Plots: Scatter plots present the distribution of detected contaminants in surface and subsurface sediment per river mile. The data are presented in a log scale (by order of magnitude) to facilitate in the discussion on distribution and to fit all the data onto one plot due to the vast range in concentrations detected. To aid in differentiating potential concentration trends in the Study Area, the data in these plots are further separated into eastern nearshore, western nearshore, and navigation channel stations as defined by the federal navigation channel boundary (Map 5.2-~~333~~⁵). Data collected in Multnomah Channel is presented with the western shore data and is identified using a different symbol. Likewise, data collected in Swan Island Lagoon is presented with the eastern shore data and identified with a unique symbol. Unlike the plan-view maps, the scatter plots do *not* include data for samples from locations that have been subsequently dredged or capped.

¹ For example, all data shown for locations *within the capped area* at the M&B site (see Maps 2.2-1i and 2.2-2i) are from surveys completed between 1999 and 2002, prior to capping. These data are shown on the surface and subsurface core plan-view maps and included in the map histograms; however, they are not included in the other sediment data presentations (i.e., scatter plots and histograms).

² Surface interval sample locations G088, G087, and G091 collected in 2004 in the International Terminals Slip were dredged subsequent to sampling. These locations were resampled in 2005 at C088, C087, and C091.

Histograms: The histograms compare the average surface and subsurface sediment chemical concentrations for the indicator contaminants on subarea basis. The y-axis in the plots is centered on a value of 0, which represents the vertical horizon (i.e., 40 cm bml) between the surface and subsurface samples. Bars extending downward from the y-axis depict the subsurface mean values. Bars extending upward show the surface sediment means. Subareas included east, navigation channel, and west zones for each river mile in the Study Area, as well as Multnomah Channel, Swan Island Lagoon, downstream reach (RM 0–2), upriver reach (RM 15.3–26), and downtown reach (RM 11.8–15.3). Mean concentrations were also calculated for each zone in the entire Study Area (see leftmost column in each figure).

These histograms are useful in providing a visual summary of spatially averaged surface/subsurface trends throughout the Study Area. However, some caution is needed in interpreting the trends due to the biased nature of the RI sampling program (i.e., subsurface core samples were generally focused on known areas of contamination, whereas surface samples were distributed more widely). Further, highly contaminated areas may not necessarily be contained within a specific river mile, but rather partially overlap two adjacent river miles. Consequently, these histograms should be examined in conjunction with the subsurface core maps in evaluating surface to subsurface trends for a specific contaminant and subarea. This is particularly true for the relative low density PCDD/F data presented in Figure 5.2-86.

5.2.1 Sediment Data Set

The sediment RI data set is composed of all Category 1 LWG and non-LWG data (refer to Table D1.3-1) collected within the Downstream reach (RM 0 to 1.9), the RI Study Area reach (RM 1.9 to 11.8), the Downtown reach (RM 11.8 to 15.3), and the Upriver reach (RM 15.3 to 28.4), from May 1997 to July 2010. The surface sediment data set includes all samples with intervals starting at 0 cm and extending to depths ranging to 40 cm bml. The subsurface data set includes all samples collected at depths greater than 40 cm bml. The Upriver reach is dynamic and the channel is coarse-grained with finer-grained sediments generally restricted to small off-channel areas (Map 5.2-50), thus, most of the main channel above RM 20 could not be sampled with a grab sampler because the river bed is cobbled or hard.

Summary statistics for indicator contaminants, percent fines, and TOC in the surface and subsurface sediment samples for the entire RI Study Area reach are presented in Tables 5.2-1 and 5.2-2. The data from the RI Study Area were segregated into the eastern shore, navigation channel, and western shore and are presented by river mile in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. These summary statistics do not include results from locations that were dredged or capped subsequent to sample collection. However, post-dredged sediment samples are included in the summary statistics. Similar summary statistics are presented for the Upriver reach in Tables 5.2-15 and 5.2-16, the Downtown reach in Tables 5.2-17 and 5.2-18, and the Downstream reach in Tables 5.2-19 and 5.2-20.

Commented [Int6]: Defined in Section 2 as RM 15.3-28.4

Commented [Integral7]: We assume this is Map H4.2-2 from the DF RI, the Upriver g-s contour map.

Commented [Int8]: The LWG never planned or attempted to collect subsurface sediments in the Upriver Reach – propose deleting this sentence.

Commented [A9]: Is there somewhere that provides the list of samples that were excluded from the statistics? If not, this must be provided in appendix D and referenced here.

Commented [Int10]: We can provide this in a summary table in the appendix. This will be a new table.

Commented [A11]: Should be time frame. Was this from Round 2? Round 3? Provide more specific language describing what is meant by this statement.

Commented [KK12R11]: Integral will provide language pointing to a table that identifies data removed to be proved in draft final document.

Commented [Int13]: Response to Comment A11: The samples that were dredged or capped also included samples collected by other parties since 1997. Dredging and capping have been performed periodically since 1997. We couldn't restrict the time reference to Round 2 or Round 3. The information is contained in the database on a sample by sample basis.

5.2.2 Total PCBs in Surface and Subsurface Sediment

The distribution of total PCB concentrations at each surface sediment sampling station throughout the Study Area is depicted on Map 5.2-1; concentrations with depth at subsurface stations are depicted on Maps 5.2-2a–o. If more than one sample was analyzed at the same surface sediment location, the greater of the two samples is presented on these maps; all subsurface samples are presented. Detailed subsurface sediment chemistry in the Study Area is presented on Maps 5.2-3a–f.

Scatter plots of the total PCB data set for surface and subsurface sediment in the Study Area are presented on Figures 5.2-1 and 5.2-2, respectively. The scatter plots present the data in three panels segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-3).

Summary statistics for total PCBs in surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2. Summary statistics for surface and subsurface sediment within the eastern nearshore, navigation channel and western nearshore zones are presented in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Tables 5.2-9 and 5.2-10 present the total PCB data as orders of magnitude (e.g., <1, 1-10, 10-100, 100-1,000, etc.) for only detected values and for combined detect and nondetect values. Finally, a histogram presenting the average surface and subsurface sediment values by river mile and for the entire Study Area is in Figure 5.2-3.

Data sets for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables. Additionally, the Downtown reach surface sediment samples are presented in Map 5.2-36. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12, number of data points by order of magnitude are provided in Tables 5.2-13 (detects only) and 5.2-14 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downtown reach are shown in Tables 5.2-15 and 5.2-16, number of data points by order of magnitude are provided in Tables 5.2-17 (detects only) and 5.2-18 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20, number of data points by order of magnitude are provided in Tables 5.2-21 (detects only) and 5.2-22 (detects and nondetects).

5.2.2.1 Total PCB Data Set

The surface and subsurface data set includes PCBs analyzed for both Aroclors and congeners. For the purpose of sediment characterization, total PCB congener concentrations represent the sum of detected congener concentrations in a sample. In cases where no congeners were detected, the single highest detection limit of all congeners analyzed is used to represent the total value. Similarly, total PCB Aroclor values reflect the sum of detected Aroclors in a sample.

The relationship between total PCB congener and total Aroclor concentrations is discussed in detail in Appendix D1.5. The coefficient of determination between same-sample congener and Aroclor totals in surface sediment was $r^2 = 0.761$, and $r^2 = 0.476$ for subsurface sediment. Plots of these regressions are presented in Appendix D1.5. For all data (sediment, sediment trap, and biota), r^2 was 0.70. PCB totals based on congeners and Aroclors did not correspond well for 11 sediment samples, an order of magnitude difference was observed between the total congener and total Aroclor results, as described in Appendix D1.5. The evaluation indicates that total Aroclor data may overpredict total PCB congeners in concentrations below $\sim 750 \mu\text{g/kg}$ total Aroclors and may underpredict above $750 \mu\text{g/kg}$. For this reason, PCB congener data was determined to better represent total PCB concentrations than Aroclor data, as the congener method is less affected by “weathering,” non-PCB interferences, and subjective Aroclor identifications.

In this report, total PCB congener concentrations are given priority over total Aroclor concentrations when total PCB congener data exist for any given sample, based on the greater specificity and accuracy of the laboratory method for congeners. Because measured total PCB concentrations are fairly comparable between methods in most cases, it is useful to use Aroclor concentrations when no PCB congener data exist, which represent the majority of the samples. Combining the PCB data in this way provides greater spatial and temporal coverage than using congener data alone due to the lack of congener data available.

The summary statistics values shown in Tables 5.2-1 and 5.2-2 for total Aroclors and total PCB congeners indicate overall higher sample concentrations of total PCB when summing congeners. The higher concentrations measured by summing congeners are not a result of differences in laboratory methodology, but rather are attributable to a more targeted sample selection process, in which samples selected for PCB congener analysis frequently targeted areas known or suspected to have relatively high PCB contamination.

Consequently, the total PCB data set consists of the result for total PCB congeners for each sample when available³, and the result for total Aroclors when no total PCB congener data are available for a particular sampling location. Congener analyses for the remaining LWG sediment samples included all 209 congeners. Total PCB concentration data for sediment within the Study Area are available for 1,318 surface and 1,543 subsurface samples. Most of the total PCB data are based on Aroclor analyses (Tables 5.2-1 and 5.2-2). Maps 5.2-4 and 5.2-5 display the locations of surface and subsurface sediment samples analyzed for PCBs and indicate whether PCB congener data, Aroclor data, or both are available.

³ The exception is that total Aroclor data were selected to represent total PCBs for Round 2A beach sediment samples because the beach samples were only analyzed for coplanar PCB congeners, which constitute a small fraction of the total PCBs.

5.2.2.2 Total PCBs in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

Total PCBs were detected in 42 of 81 surface sediment samples within the Upriver reach (frequency of detection 52 percent). Detected concentrations ranged from 0.29J µg/kg to 31 µg/kg (Table 5.2-11). Total PCBs (Tables 5.2-13 and 5.2-14) were at or greater than 10 µg/kg in 4 samples, between 1 µg/kg and 10 µg/kg in 3433 samples, and less than 1 µg/kg in 45 samples. The mean total PCB concentration in this reach is 4.48 µg/kg.

Commented [Int14]: The revisions to values called out in remainder of Section 5.2 are based on a review of the cited data tables.

Downtown Reach (RM 11.8 to 15.3)

Total PCBs were detected in 195 of 265 surface sediment samples within the Downtown reach (frequency of detection 74 percent). Detected concentrations ranged from 0.798J µg/kg to 19,700 µg/kg (Table 5.2-15a and Map 5.2-36). Concentrations reported were greater than 10,000 µg/kg in three samples, between 1,000 and 10,000 µg/kg in 12 samples, between 100 and 1,000 µg/kg in 51 samples, between 10 and 100 µg/kg in 81 samples, between 1 and 10 µg/kg in 47 samples, and less than 1 µg/kg in one sample (Tables 5.2-17 and 5.2-18).

The majority of samples with concentrations greater than 1,000 µg/kg were located along the western shoreline between RM 13.5W and 14.1W, which is the location of the Zidell facility. In 2011, a remedial action was conducted at the Zidell facility under ODEQ authority. Within the area addressed by the remedial action, total PCBs were detected in 111 surface sediment samples (frequency of detection of 73 percent). Concentrations reported ranged from 1.27 µg/kg to 19,700 µg/kg, with a mean of 1,320 µg/kg (Table 5.2-15c). When the data for the Zidell facility is removed from the downtown reach data set (Table 5.2-15b), total PCB concentrations in surface sediment ranged from 0.798J µg/kg to 4,200 µg/kg, with a mean of 108 µg/kg.

Study Area Reach (RM 1.9 to 11.8)

Total PCBs were detected in 80 percent of surface sediment samples (1,052 detections) within the Study Area. Concentrations reported ranged from 0.851J µg/kg to 35,400 µg/kg (Table 5.2-1), and varied throughout the Study Area (Figure 5.2-1). This information is presented on Map 5.2-1, total PCB concentrations exceeding 1,000 µg/kg are indicated in red on Map 5.2-1. Several prominent concentration peaks, defined as greater than 1,000 µg/kg, are present in the eastern nearshore zone: RM 1.9E-RM 4E, RM 6E-7E, Swan Island Lagoon, and RM 11E-11.8E (Figure 5.2-1). Mean total PCB concentrations in these areas are: 663 µg/kg at RM 1.9E-3E, 369 µg/kg at RM 3E-4E; 223 µg/kg at RM 6E-7E, 373 µg/kg in Swan Island Lagoon; and 495 µg/kg at RM 11E-11.8E (Table 5.2-3).

The highest total PCB concentrations along the western side of the river are found in the western nearshore zone from RM 8W-10W; including the highest detected surface

concentration (35,400 µg/kg) at Station G453 (RM 8.8W). Mean total PCB concentrations in this area are 978 µg/kg at RM 8W-9W and 341 µg/kg at RM 9W-10W (Table 5.2-7).

The highest concentrations found in the navigation channel zone are at RM 11 to 11.8, which appears to be an extension of the contamination noted along the eastern nearshore area (Map 5.2-1). The maximum detected concentration in this area was 5,900 µg/kg, with a mean concentration 292 µg/kg (Table 5.2-5).

Total PCB concentrations greater than 10,000 µg/kg were found in only two locations; in the western nearshore zone at RM 8.8W, and in Swan Island Lagoon (Tables 5.2-9 and 5.2-10; Maps D1.2-tv and D1.2-tx). Total PCB concentrations between 1,000 and 10,000 µg/kg were reported in 37 samples, all within the areas described above. Overall, concentrations greater than 1,000 µg/kg account for four percent of detected results (39 samples), 19 percent were between 100 and 1,000 µg/kg (203 samples), 59 percent (621 samples) were between 10 and 100 µg/kg, 18 percent (188 samples) were between 1 and 10 µg/kg, and one sample was detected at a concentration less than 1 µg/kg (Map 5.2-1; Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Total PCBs were detected in 16 of 25 surface sediment samples within the Downstream reach. Concentrations reported ranged from 1.03 µg/kg to 410 µg/kg (Table 5.2-19), with a single result greater than 1,000 µg/kg (Tables 5.2-21 and 5.2-22). Overall, concentrations between 100 and 1,000 µg/kg account for 38.16 percent of detected results (84 samples), 52.44 percent were between 10 and 100 µg/kg (11 samples), and one between 1 and 10 µg/kg. The mean total PCB concentration in this reach is 34.33.7 µg/kg.

5.2.2.3 Total PCBs in Subsurface Sediment

Upriver Reach (RM 15.3 to 28.4)

Three subsurface sediment samples were analyzed for total PCBs within the Upriver reach between RM 15.4 and 16. All results were reported as nondetect, with a maximum reporting limit of 11 µg/kg (Table 5.2-12).

Downtown Reach (RM 11.8 to 15.3)

Total PCBs were detected in 59 of 110 subsurface sediment samples within the Downtown reach. Concentrations reported ranged from 1.4 µg/kg to 610 µg/kg (Table 5.2-16a) with a mean concentration of 92 µg/kg. Within this reach, 14 percent (15 samples) of the reported results were between 100 and 1,000 µg/kg, 44 percent (31 samples) were between 10 and 100 µg/kg, and 22 percent (13 samples) were between 1 and 10 µg/kg. All detected results were greater 1 µg/kg (Tables 5.2-17 and 5.2-18).

Only two subsurface samples were collected from the vicinity of the Zidell facility, the reported concentrations were 140 µg/kg and 190 µg/kg.

Study Area Reach (RM 1.9 to 11.8)

Total PCBs were detected in 939 subsurface samples within the Study Area (detection frequency of 61 percent), with detected concentrations ranging from 0.00138 J µg/kg to 36,800 µg/kg (Table 5.2-2). Similar to surface sediment, total PCB concentrations in the subsurface also varied within the Study Area. Several areas of higher concentrations (greater than 1,000 µg/kg) in the subsurface data are identified in the eastern nearshore zone (Figure 5.2-2, Maps 5.2-2a-o and 5.2-3a-ffgg) from RM 1.9E-4E, RM 5E-6E, Swan Island Lagoon, and RM 11E-11.8E. Mean concentrations in these areas are: 521 µg/kg at RM 1.9E-3E, 1,530 µg/kg at RM 3E-4E, 369 µg/kg at RM 5E-6E, 560 µg/kg in Swan Island Lagoon, and 464 µg/kg at RM 11E-11.8E (Table 5.2-4).

An area of high total PCB concentrations is located in the western nearshore zone from RM 7W-10W. The highest subsurface concentration of 36,800 µg/kg was reported in the sample from Station C455 at 30–1542 cm bml (Map 5.2-3v). Mean total PCB concentrations in this area are 177 µg/kg at RM 7W-8W, 931 µg/kg at RM 8W-9W, and 424 µg/kg at RM 9W-10W (Table 5.2-8).

The highest reported concentrations in the Navigation Channel are at RM 10-11.8. Mean total PCB concentrations in this area are: 443 µg/kg at RM 10-11 and 107 µg/kg at RM 11-11.8 (Table 5.2-6). The higher concentrations at RM 10-11 appear to be associated with the western nearshore area, whereas concentrations at RM 11-11.8 appear to be associated with the eastern nearshore area (Maps 5.2-2l and m).

Commented [Integral15]: Propose deleting this statement, "total area" implies the areal extent was quantified.

Overall, 6 samples had reported total PCB concentrations greater than 10,000 µg/kg. These were located in the eastern nearshore zone from RM 3E-4E, Swan Island lagoon, and the western nearshore zone from RM 8W-9W (Tables 5.2-9 and 5.2-10; Maps 5.2-3a-gg). An additional 40 samples had reported concentrations between 1,000 and 10,000 µg/kg, all were located within the areas described above. Total PCB concentrations in subsurface sediment greater than 1,000 µg/kg account for five percent of the detected results, 34 percent (319 samples) were between 100 and 1,000 µg/kg, 50 percent were between 10 and 100 µg/kg, nine percent (88 samples) were between 1 and 10 µg/kg, and two percent (20 samples) had reported concentrations less than 1 µg/kg.

Downstream Reach (RM 0 to 1.9)

Total PCBs were reported in 13 of 26 subsurface sediment samples within the Downstream reach. Concentrations reported ranged from 5 µg/kg to 250 µg/kg (Table 5.2-20). Three samples had reported concentrations between 100 and 1,000 µg/kg, 62 percent (8 samples) had reported at concentrations between 10 and 100 µg/kg, and two samples had reported concentrations between 1 and 10 µg/kg. The mean total PCB concentration in this reach is 67 µg/kg (Tables 5.2-21 and 5.2-22).

5.2.2.4 Total PCB Surface and Subsurface Sediment Relationships

The relationship between surface and subsurface sediment total PCB concentrations were examined by comparing surface and subsurface concentrations by reach, and also by subareas within the Study Area.

There are insufficient data to compare surface and subsurface concentrations in the Upriver reach because no attempt was made to characterize subsurface sediments in this reach. This reach is unlikely to have significant subsurface contamination due to its dynamic (i.e., non-depositional) nature. The mean surface sediment concentration in this reach is 4.48 µg/kg. Subsurface samples were non-detect for total PCBs, with a reporting limit of 11 µg/kg.

Commented [Int16]: As noted above, there was never any intention to characterize subsurface sediments in the upriver reach. Proposed revision to clarify this.

Within the downtown reach, Total PCB concentrations were higher in surface sediment than in subsurface sediment. Mean concentrations are 612 and 92 µg/kg in surface and subsurface sediment, respectively. Median concentrations are 45 µg/kg and 41 µg/kg in surface and subsurface sediments, respectively.

Total PCB concentrations are generally greater in subsurface sediments than in surface sediments within the Study Area. The mean surface sediment concentration in the Study Area is 220 µg/kg and the mean subsurface sediment concentration is 351 µg/kg (Tables 5.2-1 and 5.2-2). Median total PCB concentrations in surface and subsurface sediment are, respectively, 26.9 µg/kg and 70.0 µg/kg. Mean concentrations are greater in the nearshore areas than in the navigation channel. PCB concentrations are greater in the eastern nearshore zone than the western nearshore zone, and are generally greater in the subsurface sediment than in surface sediment (Figure 5.2-3).

Subsurface sediment concentrations are greater than surface sediment In the eastern nearshore zone in all river miles zones except from RM 1.9-3, RM 6-7, RM 10-11, and RM 11-11.8. In the western nearshore zone, subsurface sediment concentrations are greater than in surface sediment in all river miles except RM 8W-9W. The subsurface sediment concentrations in the navigation channel are generally greater than the surface sediment concentrations, except from RM 11-11.8.

Areas where subsurface sediment total PCB concentrations exceed 1,000 µg/kg generally align with the locations where surface sediment concentrations are greater than 1,000 µg/kg (Maps 5.2-2a-o and 5.2-3a-ffgg; Figures 5.2-1, 5.2-2 and 5.2-3). Exceptions occur in the eastern nearshore zone, PCB concentrations greater than 1,000 µg/kg in surface sediment are found from RM 6E-7E and in subsurface sediment from RM 5E-6E.

Commented [Integral17]: Concentrations >1,000 in both surface and subsurface near RM 9W, so propose deleting this statement

The subsurface sediment concentrations in the downstream reach were greater than surface concentrations. The mean total PCB concentrations are 34-33.7 µg/kg and 67 µg/kg in surface and subsurface sediment, respectively. The median total PCB

concentrations are 6.8 µg/kg and 46 µg/kg in surface and subsurface sediment, respectively.

5.2.3 Total PCDD/Fs and TCDD TEQ in Sediment

Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans are evaluated as total polychlorinated dibenzo dioxins/furans (total PCDD/Fs). The summed total value for total PCDD/Fs represent the summed value of the measured homolog concentrations. The toxicity of dioxins and furans is determined by both the number and the position of the chlorine on the molecule, and appears to be a function of the ability to bind to specific cellular receptors. Because only those congeners having a chlorine in each of the 2, 3, 7, and 8 positions exhibit a toxicological response similar to 2,3,7,8-TCDD and other 2,3,7,8 substituted isomers appear to be slightly to substantially less potent, a toxicity equivalent factor is used to calculate a PCDD or PCDF toxicity equivalent concentration by multiplying the individual congener concentrations by its respective toxicity TEF. The TCDD TEQ represents the sum of the individual 2,3,7,8-TCDD equivalent concentrations.

The distribution of total PCDD/Fs and TCDD TEQ concentrations at each surface sampling station throughout the Study Area is depicted on Maps 5.2-6 and 5.2-8, respectively; concentrations with depth at subsurface stations are depicted in Maps 5.2-7a-o and 5.1-9a-o, respectively. Detailed subsurface sediment chemistry in the Study Area is presented on Maps 5.2-10a-l, including a key for interpreting the detailed subsurface chemistry maps.

The complete data set for total PCDD/Fs is plotted on scatter plots presented on Figures 5.2-4 and 5.2-5. Figures 5.2-7 and 5.2-8 present scatter plots of the TCDD TEQ data set for surface and subsurface sediment in the study area, respectively. The scatter plots present the data in three panels segregated by the eastern nearshore, navigation channel, and western nearshore zones (Map 5.2-~~33~~35).

Summary statistics for total PCDD/Fs and TCDD TEQ in surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2. Summary statistics for surface and subsurface sediment within the eastern nearshore, navigation channel and western nearshore zones are presented in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Tables 5.2-9 and 5.2-10 present the total PCDD/Fs and TCDD TEQ data as orders of magnitude (e.g., <1, 1-10, 10-100, 100-1,000, etc.) for only detected values and for combined detect and nondetect values. Finally a histogram presenting the average surface and subsurface sediment values for total PCDD/Fs and TCDD TEQ by river mile and for the entire Study Area is presented in Figures 5.2-6 and 5.2-9.

Data sets for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables. Additionally, the Downtown reach surface sediment samples are presented on Map 5.2-37 and 5.2-38.

Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12; number of data points by order of magnitude are provided in Tables 5.2-13 (detect only) and 5.2-14 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downtown reach are shown in Tables 5.2-15 and 5.2-16; number of data points by order of magnitude are provided in tables 5.2-17 (detect only) and 5.2-18 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20; number of data points by order of magnitude are provided in Tables 5.2-21 (detect only) and 5.2-22 (detect and nondetect).

5.2.3.1 Total PCDD/Fs and TCDD TEQ Data Sets

The number of sediment samples for PCDD/F analysis was based on a biased approach at locations near known or suspected sources. As a result, there are fewer data points for these analytes and the resulting TCDD TEQ data in the RI sediment database than for other chemicals (for example, the PCDD/F data set is approximately one-fifth the size of the PCBs and DDx data sets). This is particularly true in areas not proximal to suspected sources, such as the navigation channel.

While the existing PCDD/F data are sufficient for RI purposes, the fewer number of data points limits the level of detail to which the extent of the chemical contaminant distribution may be resolved in some areas and introduces the need for caution in interpreting the surface to subsurface trends shown by the histograms (Figures 5.2-6 and 5.2-9), and in making conclusions regarding the spatial patterns of the composition of total PCDD/Fs and TCDD TEQ in sediment (Sections 5.2.3.2 through 5.2.3.5). Total PCDD/Fs data for sediment within the Study Area are available for 237 surface and 327 subsurface samples; there are 238 surface and 331 subsurface samples in the Study Area sediment TCDD TEQ data set.

5.2.3.2 Total PCDD/Fs in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

Total PCDD/Fs were reported in 38 of 39 surface sediment samples within the Upriver reach (frequency of detection 97 percent). Concentrations range from 2.39 (0.00239 µg/kg) to 733 pg/g (Table 5.2-11). Concentrations between 100 and 1,000 pg/g were reported in 12 samples (Tables 5.2-13 and 5.2-14), between 10 and 100 pg/g in 17 samples, and between 1 and 10 pg/g in 9 samples. The mean total PCDD/Fs concentration in this reach is 90 pg/g, the median is 59 J pg/g.

Downtown Reach (RM 11.8 to 15.3)

Total PCDD/Fs were detected in 62 of 67 surface sediment samples within the Downtown reach (frequency of detection of 93 percent). Detected concentrations ranging from 9.45 J pg/g to 15,400 J pg/g (Table 5.2-15a) with a mean of 1,130 pg/g. As shown on Map 5.2-37, the highest detected concentrations are located along the eastern shoreline. Concentrations greater than 10,000 pg/g were reported in a single

sample, between 1,000 and 10,000 pg/g in 17 samples, between 100 and 1,000 pg/g in 26 samples, between 10 and 100 µg/kg in 16 samples, and between 1 and 10 pg/g in 2 samples. This information is presented in Tables 5.2-17 and 5.2-18.

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. None of the total PCDD/F data was excluded from the Downtown reach.

Study Area Reach (RM 1.9 to 11.8)

Total PCDD/Fs were detected in all 237 surface sediment sampled. Reported concentrations ranged from 2.48 to 264,000 pg/g (Table 5.2-1), the mean is ~~2,407~~2,410 pg/g, and the median is 412 pg/g. Detected concentrations exceeding 2,000 pg/g are indicated in red on Map 5.2-6. Total PCDD/F concentrations exceeding 1,000 pg/g are found in the eastern nearshore zone at RM ~~2E-8E~~, Swan Island Lagoon, and at RM ~~11E~~ (Figure 5.2-4). Mean concentrations (see Table 5.2-3) in these areas are 1,170 pg/g at RM ~~3E-4E~~; 1,640 pg/g at RM ~~4E-5E~~, 1,300 pg/g at RM ~~5E-6E~~, 3,440 pg/g at RM ~~E6-7E~~, 1,510 pg/g at RM ~~7E-8E~~, 3,030 pg/g in Swan Island Lagoon, and ~~4,540~~1,670 pg/g at RM ~~11E-11.8E~~.

Concentrations exceeding 1,000 pg/g are found in the western nearshore zone at RM ~~6W-10W~~ and from RM ~~4W-6W~~. Mean concentrations (see Table 5.2-7) in these locations are 726 pg/g at RM ~~4W-5W~~, 830 pg/g at RM ~~5W-6W~~; 1,730 pg/g for RM ~~6W-7W~~; 15,200 pg/g at RM ~~7W-8W~~; 1,500 pg/g at RM ~~8W-9W~~; and ~~4,690~~1,650 pg/g at RM ~~9W-10W~~. The highest surface sediment concentration (264,000 pg/g) in the data set was detected between RM ~~7W-8W~~.

The highest total PCDD/F concentrations in the navigation channel zone are located at RM 6-7 and from RM 11-11.8. It appears that these concentrations are associated with higher concentrations found in the eastern nearshore zone (Map 5.2-6) rather than reflecting conditions in the navigation channel. The maximum detected concentrations at these locations are 2,260 pg/g at RM 6-7, and 2,020 pg/g at RM 11-11.8. Mean concentrations are 779 pg/g at RM 6-7 and 810 pg/g at RM 11-11.8 (Table 5.2-5).

Total PCDD/F concentrations greater than 10,000 pg/g were detected in seven samples (Tables 5.2-9 and 5.2-10), ~~2763~~ detected values are between 1,000 and 10,000 pg/g. Overall, concentrations greater than 1,000 pg/g account for 30 percent of the detected results (Map 5.2-6), 56 percent (133 samples) were between 100 and 1,000 pg/g, 13 percent (31 samples) were between 10 and 100 pg/g, and 1 percent (three samples) were detected at concentrations between 1 and 10 pg/g.

Total PCDD/F concentrations greater than 2,000 pg/g (indicated in red on Map 5.2-6) were found at several locations along the eastern and western nearshore zones. Limited surface PCDD/F data are available in the navigation channel, and spatial resolution is

somewhat limited. However, of the channel samples that were analyzed, most concentrations were less than 500 pg/g (except as noted above) and a pattern is evident of relatively high concentrations in nearshore areas compared with lower concentrations in the adjacent channel areas.

Downstream Reach (RM 0 to 1.9)

Total PCDD/Fs were detected in all 21 samples within the Downstream reach. Concentrations reported ranged from 1.56 J pg/g to 1,780 J pg/g, with a mean concentration of 232 pg/g (Table 5.2-19). Tables 5.2-21 and 5.2-22 show that there was only 1 data point with a concentrations greater than 1,000 pg/g, ~~were reported in 3 samples~~, 38 percent (eight samples) of the reported concentrations were between 100 and 1,000 pg/g, 52 percent (11 samples) were between 10 and 100 pg/g, and 1 sample between 1 and 10 pg/g.

5.2.3.3 Total PCDD/Fs in Subsurface Sediment

Upriver Reach (RM 15.3 to 28.4)

Total PCDD/Fs were detected in all three subsurface sediment samples in the Upriver reach, reported concentrations ranged from 3.59 pg/g to 1,090 pg/g (Table 5.2-12) with mean concentration of 816 pg/g. One sample had a reported concentration between 1,000 and 10,000 pg/g, the other two results were between 100 and 1,000 pg/g (Tables 5.2-13 and 5.2-14).

Downtown Reach (RM 11.8 to 15.3)

Total PCDD/Fs were detected in 39 of 44 subsurface sediment samples and samples within the Downtown reach (detection frequency of 89 percent), with detected concentrations ranging from 4.74 pg/g to 4,590 J pg/g (Table 5.2-15a) and a mean concentration of 1,090 pg/g. Overall, concentrations between 1,000 and 10,000 pg/g were reported in 17 samples, 11 were between 100 and 1,000 pg/g, eight were between 10 and 100 µg/kg, and three were between 1 and 10 pg/g. There were no detected results less than 1 pg/g (Tables 5.2-17 and 5.2-18).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-16b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-16c presents the data statistics for the Zidell data removed from the Downtown data set. None of the total PCDD/Fs data was excluded from the Downtown reach.

Study Area Reach (RM 1.9 to 11.8)

Total PCDD/Fs were detected in 325 of 327 subsurface sediment samples within the Study Area (frequency of detection 99 percent). Reported concentrations ranged from 0.0578 J pg/g to 425,000 J pg/g, with a mean concentration of ~~9,0529,050~~ pg/g

(Table 5.2-2). The distribution of reported concentrations is presented on Figure 5.2-5 and Maps 5.2-47a-o).

Total PCDD/F concentrations in subsurface sediment greater than 10,000 pg/g were found in the eastern nearshore zone from RM ~~6-7E-8E~~ in Swan Island Lagoon, and ~~from RM 11-11.8~~ (Figure 5.2-5). Concentrations greater than 1,000 pg/g in subsurface sediment are prevalent throughout the site, most frequently in the eastern nearshore zone from RM 2E through 8E and RM 11E-11.8E. Mean concentrations (see Table 5.2-4) in the eastern nearshore zone are 446 pg/g at RM 1.9E-3E; 638 pg/g at RM 3E-4E; 1,340 pg/g at RM 4E-5E; 561 at RM 5E-6E; 1,650 pg/g at RM 6E-7E; 19,500 pg/g at RM 7E-8E; 981 pg/g in Swan Island Lagoon; and 1,510 pg/g at RM 11E-11.8E.

Total PCDD/F concentrations exceed 10,000 pg/g between RM 6W and ~~89W~~ in the western nearshore zone that (Figure 5.2-5). Reported concentrations greater than 1,000 pg/g are located from RM 4W through 11W. The highest reported concentration of 425,000 J pg/g was found in core sample ~~C455WB-36 (30-152 cm bml)~~ ~~RM 8.8~~ between RM 7W and 8W (Table 5.2-68). Mean concentrations in subsurface sediment in the western nearshore zone are ~~287,624~~ pg/g at RM 4W-5W, ~~33-315~~ pg/g at RM 5W-6W, ~~3752,650~~ pg/g at RM 6W-7W, ~~2,270,27,300~~ at RM 7W-8W, 19,400 pg/g at RM 8W-9W, and ~~26912,200~~ pg/g at RM 9W-10W.

Limited subsurface sediment data are available for the navigation channel, most reported concentrations were less than 100 pg/g. The highest concentrations in the subsurface samples are generally found in the same areas where concentrations greater than 1,000 pg/g were reported in surface samples (Figures 5.2-5 and 5.2-6; Maps 5.2-7a-o). Reported concentration greater than 1,000 pg/g were found from RM 6-7 and RM ~~11-11.8~~ 9.5 to 10.5.

Total PCDD/F concentrations greater than 10,000 pg/g were reported in 26 samples, 71 were between 1,000 and 10,000 pg/g (Tables 5.2-9 and 5.2-10), and overall 30 percent of the reported concentrations were greater than 1,000 pg/g. Reported concentrations between 100 and 1,000 pg/g comprise 32 percent (103 samples) of the detections, 23 percent (74 samples) were between 10 and 100 pg/g, 10 percent (31 samples) were between 1 and 10 pg/g, and 6 percent (20 samples) were less than 1 pg/g.

Downstream Reach (RM 0 to 1.9)

Total PCDD/Fs were detected in 17 of 17 samples analyzed within the Downstream reach. Reported concentrations ranged from 0.093 pg/g to 967 pg/g, the mean concentration is 145 pg/g (Table 5.2-20). Overall, concentrations greater than 100 pg/g account for 29 percent (5 samples) of the detected results, 41 percent (7 samples) were between 10 and 100 pg/g, 12 percent (2 samples) were between 1 and 10 pg/g, and 18 percent (3 samples) were detected at concentrations less than 1 pg/g (Tables 5.2-21 and 5.2-22).

5.2.3.4 TCDD TEQ in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

TCDD TEQ were calculated for 48 of 49 surface sediment samples within the Upriver reach. Calculated concentrations range from 0.00684 J pg/g to 2.99 pg/g (Table 5.2-11). Tables 5.2-13 and 5.2-14 show that there are three results are between 1 and 10 pg/g, the majority (4245 samples; 8892 percent) are less than 1 pg/g. The mean TCDD TEQ concentration in this reach is 0.300.315 pg/g.

Downtown Reach (RM 11.8 to 15.3)

TCDD TEQ were calculated 63 of 67 surface sediment samples within the Downtown reach, with concentrations ranging from 0.011 J pg/g to 19.2 J pg/g with a mean of 2.61 pg/g (Table 5.2-15a). TCDD TEQ concentrations in surface sediment in the Downtown reach are shown in Map 5.2-38. Two results are between 10 and 100 pg/g, 35 detected (56 percent) are between 1 and 10 pg/g, and 26 (41 percent), are less than 1 pg/g (Tables 5.2-17 and 5.2-18).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. None of the TCDD TEQ data was excluded from the Downtown reach.

Study Area Reach (RM 1.9 to 11.8)

TCDD TEQ were calculated for 238 surface sediment samples. Calculated concentrations range from 0.008 J to 14,100 J pg/g, with a mean of 68.67.9 pg/g (Table 5.2-1). These results are plotted on Figure 5.2-7 and presented on Map 5.2-8, concentrations greater than 10 pg/g are indicated in red.

Total TCDD TEQ greater than 10 pg/g are present in the eastern nearshore from RM 63E through 8E, in Swan Island Lagoon, and RM 11E-11.8E. Mean concentrations (see Table 5.2-3) in these areas are 2.95 pg/g at RM 3E-4E, 4.84 pg at RM 4E-5E, 4.40 pg/g at RM 5E-6E, 16.1 pg/g at RM 6E-7E, 42.11.9 pg/g for RM 7E-8E, 4.90 pg/g in Swan Island Lagoon, and 4.44 pg/g at RM 11E-11.8E.

Total TCDD TEQ concentrations greater than 10 pg/g in the western nearshore zone are present from RM 6W to 10W. Mean concentrations (see Table 5.2-7) in these areas are 20.0 pg/g at RM 6W-7W, 79.78.5 pg/g at RM 7W-8W, 3.63.55 pg/g at RM 8W-9W, and 4.64.59 pg/g at RM 9W-10W. The highest calculated TEQ concentration in surface sediment of 14,100 pg/g in the data set is between RM 7W and 8W.

There were no calculated concentrations in the navigation channel zone greater 10 pg/g.

Only one sample has calculated TCDD TEQ greater than 10,000 pg/g, there are no results between 1,000 and 10,000 pg/g, 4 results (2 percent) are between 100 and 1,000 pg/g, 28 results (12 percent) are between 10 and 100 pg/g, 107 samples (45 percent) are between 1 and 10 pg/g, and 98 results (41 percent) are less than 1 pg/g (Tables 5.2-9 and 5.2-10).

The spatial distribution TCDD TEQ values in the Study Area is presented on Figure 5.2-7. Concentrations were higher in the western nearshore zone than in the eastern nearshore or navigation channel. The highest reported results are present in the western nearshore between RM 6.8 and 7.3, where the sample density is greater in comparison to the rest of the Study Area.

Limited data for TCDD TEQ are available for sediments in the navigation channel (Map 5.2-8). TCDD TEQ surface values within the channel were all less than 10 pg/g.

Downstream Reach (RM 0 to 1.9)

TCDD TEQ were analyzed and detected in all 21 samples within the Downstream reach, with concentrations ranging from 0.0051 J pg/g to 2.6 J pg/g (Table 5.2-19). Tables 5.2-21 and 5.2-22 show that there are only 2 data points with concentrations ranging between 1 and 10 pg/g. The majority of the data set (19 samples; 90 percent) were detected at concentrations less than 1 pg/g. The mean TCDD TEQ concentration in this reach is 0.4 pg/g.

5.2.3.5 TCDD TEQ in Subsurface Sediment

Upriver Reach (RM 15.3 to 28.4)

TCDD TEQ were calculated in 3 subsurface sediment samples within the Upriver reach, concentrations range from 0.66-656 pg/g to 2.63 pg/g (Table 5.2-12). Two results are between 1 and 10 pg/g, the remaining two results are less than 1 pg/g, with a mean concentration of 2-1.55 pg/g (Tables 5.2-13 and 5.2-14).

Downtown Reach (RM 11.8 to 15.3)

TCDD TEQ were calculated for 41 of 44 subsurface sediment samples within the Downtown reach. Calculated concentrations range from 0.00230-0.00226 J pg/g to 13-12.8 pg/g (Table 5.2-15a), with a mean of 2-72.65 pg/g. There is a single result between 10 and 100 pg/g, 24 samples (59 percent) are between 1 and 10 pg/g, 16 samples (39 percent) are less than 1 pg/g (Tables 5.2-17 and 5.2-18).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-16b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-16c presents the data statistics for the Zidell data removed from the Downtown data set. None of the TCDD TEQ data was excluded from the Downtown reach.

Study Area Reach (RM 1.9 to 11.8)

TCDD TEQ was calculated for 238313 of 331 subsurface sediment samples within the Study Area. Calculated concentrations range from 0.00030.000262 J to 24,400 J pg/g, with a mean of 433434 pg/g (Table 5.2-2). The distribution of TCDD TEQ concentrations in subsurface sediment in the Study Area is shown on Figure 5.2-8, concentrations greater than 10 pg/g are indicated in red on Maps 5.2-9a-o and 5.2-10a-l.

Concentrations greater than 10 pg/g are present in the eastern nearshore zone from RM 1.9E-3E, RM 6E through 8E, and from RM 11E to 11.8E. Mean concentrations (see Table 5.2-4) in these areas are 1.45 pg/g at RM 1.9E-3E, 5.80 pg/g at RM 6E-7E, 38 37.6 pg/g at RM 7E-8E, and 7.77.67 pg/g at RM 11E-11.8E.

Concentrations greater than 10 pg/g are present in the western nearshore zone from RM 4W through 9W, with a prominent peak from RM 6.5W to 7.W5. Mean concentrations (see Table 5.2-8) in these areas are 5.35.27 pg/g at RM 4-5, 2.52.46 pg/g at RM 5-6, 20.4 pg/g at RM 6 to 7, 731.570 pg/g at RM 7-8, and 37-36.7 pg/g at RM 8-9. The highest calculated TCDD TEQ concentration of 24,400 pg/g in subsurface sediment is located between RM 6.57.0 and 7.5. The maximum calculated subsurface TCDD TEQ value is at Station SD092 (0-90 cm vertically composited sample) at RM 7.2W (Map 5.2-9h).

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Limited subsurface TCDD TEQ data are available from the navigation channel, and the majority of calculated results are less than 10 pg/g. The highest concentrations in subsurface sediment are generally found at the same locations where TCDD TEQ are concentrations greater than 10 pg/g in surface sediment along the eastern and western nearshore zones (Maps 5.2-9a-o and 5.2-10a-l).

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Tables 5.2-9 and 5.2-10 show that there are 3 data points greater than 10,000 pg/g. There are 14 detected values between 1,000 and 10,000 pg/g and 12 samples detected at concentrations between 100 and 1,000 pg/g. An additional 42 samples are detected at concentrations ranging between 10 and 100. Another 99 samples, or 32 percent, are detected at concentrations between 1 and 10 pg/g. Approximately half the detected data set (143 samples; 46 percent) is comprised of sample concentrations less than 1 pg/g.

The data show that TCDD TEQ values vary spatially along the length of the Study Area (Figure 5.2-8). In general, values were higher in the western nearshore zone than in the eastern nearshore and navigation channel zones. The most significant peak in the data in the western nearshore occurred between approximately RM 6.8 and 7.3, where data points are relatively dense in comparison to the rest of the Study Area.

Limited data for TCDD TEQ are available for sediments in the navigation channel (Map 5.2-8). TCDD TEQ surface values within the channel were relatively low, with the exception of one sample with relatively elevated concentrations near the western channel boundary at RM 6.6 (33.3 J pg/g in the interval from 132 to 243 cm bml at Station C314; Figure 5.2-8).

Downstream Reach (RM 0 to 1.9)

TCDD TEQ were analyzed in 17 samples within the Downstream reach and detected in 16 samples (detection frequency of 94 percent), with concentrations ranging from ~~0.0030~~0.00252 pg/g to 1.53 J pg/g (Table 5.2-20). Tables 5.2-21 and 5.2-22 show that there is only one data point with concentrations ranging between 1 and 10 pg/g. The majority of the data set (15 samples; 94 percent) were detected at concentrations less than 1 pg/g. The mean TCDD TEQ concentration in this reach is 0.260 pg/g.

5.2.3.6 Total PCDD/F and TCDD TEQ Surface and Subsurface Sediment Relationships

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Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentrations by reach and also by subareas within the Study Area reach. There is insufficient data to compare surface and subsurface concentrations in the Upriver reach.

The surface total PCDD/Fs sediment concentrations in the downtown reach are slightly higher than the subsurface concentrations while the TCDD TEQ concentrations are approximately the same. The mean surface total PCDD/Fs concentration is 1,130 pg/g and the subsurface concentration is 1,090 pg/g. The surface TCDD TEQ concentration is 2.61 pg/g while the subsurface sediment concentration is ~~2.72~~2.66 pg/g.

Total PCDD/Fs and TCDD TEQ concentrations are generally greater in the subsurface sediments than in surface sediments within the Study Area as a whole. The mean total PCDD/Fs surface sediment concentration is ~~2,407~~2,410 pg/g and the subsurface concentration is ~~9,052~~9,050 pg/g; the mean total TCDD TEQ surface sediment concentration is 68 pg/g and the subsurface concentration is 434 pg/g. Most areas throughout the Study Area reach lack a strong or consistent vertical concentration gradient. This pattern may be due to the lack of samples and is supported by Maps 5.2-10a-l.

Some exceptions to this include the area under and just upstream of the Railroad Bridge at RM 6.9, where surface layers show higher concentrations than at depth (Map 5.2-10g) and the northwest corner of Willbridge Terminal where higher levels are evident at depth (Map 5.2-10h). This suggests a ~~current-recent~~ source or sources at the former location and an historical source or sources at the latter. Elsewhere in the Study Area, significant changes in the level of PCDD/F inputs over time are generally not indicated by the data collected.

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The surface total PCDD/Fs sediment concentrations in the downstream reach are slightly higher than the subsurface concentrations while the TCDD TEQ concentrations are approximately the same. The mean surface total PCDD/Fs concentration is 232 pg/g and the subsurface concentration is 67 pg/g. The surface TCDD TEQ concentration is 0.401 pg/g while the subsurface sediment concentration is ~~0.32~~0.260 pg/g.

5.2.4 DDx in Sediment

DDx represents the sum of the 2,4'- and 4,4'- isomers of DDD, DDE, and DDT. The distribution of DDx concentrations at each surface sediment sampling station throughout the Study Area is depicted on Map 5.2-11; concentrations with depth at subsurface stations are depicted on Maps 5.2-12a-o. If more than one sample was analyzed at the same surface sediment location, the greater of the two samples is presented on these maps; all subsurface samples are presented. Detailed subsurface sediment chemistry in the Study Area is presented on Maps 5.2-13a-gg, including a key for interpreting the detailed subsurface chemistry maps.

Figures 5.2-10 and 5.2-11 present scatter plots of the DDx data set for surface and subsurface sediment in the Study Area, respectively. The scatter plots present the data in three panels segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-~~3335~~).

The summary statistics for total DDx in the surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2. Summary statistics for surface and subsurface sediment within the eastern nearshore, navigational channel and western nearshore zones are presented in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Tables 5.2-9 and 5.2-10 present the total DDx data as orders of magnitude (e.g., <1, 1-10, 10-100, 100-1,000, etc.) for only detected values and for combined detect and nondetect values. Finally, a histogram presenting the average surface and subsurface sediment values by river mile and for the entire Study Area is in Figure 5.2-12.

Data for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables. Additionally, surface sediment sample locations within the Downtown reach are presented in Map 5.2-39. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12; number of data points by order of magnitude are provided in Tables 5.2-13 (detect only) and 5.2-14 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downtown reach are shown in Tables 5.2-15 and 5.2-16; number of data points by order of magnitude are provided in Tables 5.2-17 (detect only) and 5.2-18 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20; number of data points by order of magnitude are provided in Tables 5.2-21 (detect only) and 5.2-22 (detect and nondetect).

The individual total DDT, DDD, and DDE concentrations (totals of the 2,4'- and 4,4'- isomers) are depicted in similar maps, tables and figures as total DDx in Appendix D1.

5.2.4.1 DDx in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

DDx was reported in 56 of 81 surface sediment samples within the Upriver reach (frequency of detection 69 percent). Concentrations reported range from ~~0.09~~0.087 ~~J~~ to ~~15.1~~14.6 ~~J~~ µg/kg (Table 5.2-11). Tables 5.2-13 and 5.2-14 show that there is one result was reported at a concentration greater than 10 µg/kg, ~~7341~~ were between 1 and 10 µg/kg, 14 samples (25 percent) were reported at a concentration less than 1 µg/kg. The mean concentration in this reach is 2.01 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

Total DDx was reported in 130 of 149 surface sediment samples within the Downtown reach (frequency of detection 87 percent). Reported concentrations range from ~~0.95~~0.047 ~~J~~ to 73.3 ~~J~~ µg/kg (Table 5.2-15a), with a mean concentration of 6.6 µg/kg. The spatial distribution of DDx in surface sediment is presented on Map 5.2-39.

DDx concentrations between 10 and 100 µg/kg were reported in 25 samples, 76 results (58 percent) were between 1 and 10 µg/kg, and 29 samples were reported at concentrations less than 1 µg/kg (Tables 5.2-17 and 5.2-18).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. None of the total DDx data was excluded from the Downtown reach.

Study Area Reach (RM 1.9 to 11.8)

DDx was reported in 1,130 of 1,249 surface sediment samples within the Study Area (frequency of detection 90 percent). Concentrations reported range from 0.051 NJ to 84,900 µg/kg (Table 5.2-1). The spatial distribution of DDX concentrations in surface sediment is presented on Figure 5.2-10 and Map 5.2-11, concentrations greater than 100 µg/kg are observed at several locations along the nearshore zones and channel margins.

DDx concentrations greater than 100 µg/kg ~~Areas~~ are present in the eastern nearshore zone where at RM 5-7, Swan Island Lagoon, and RM 11E-11.8E (Map 5.2-11). Mean concentrations in these areas are 16.6 ug/kg at RM 5-6, 18.2 µg/kg at RM 6-7, 16-15.7 µg/kg in Swan Island Lagoon and 42.0 µg/kg at RM 11E-11.8E (Table 5.2-3).

DDx concentrations greater than 100 µg/kg are present in the western nearshore zone from RM 3W through RM 9W. The most prominent areas are between RM 6.3W and 7.5W, where concentrations greater than 10,000 µg/kg were found at ~~Station OSS002 near RM 7.2E~~ (Table 5.2-7; Map 5.2-11). DDx was reported at a concentration greater than 1,000 µg/kg in a single sample at RM 8.8W. Mean DDx concentrations in these areas in the are 27-26.6 µg/kg at RM 3W-4W, 23.4 µg/kg at RM 4W-5W, 36.3 µg/kg at RM 5W-6W, 190 µg/kg at RM 6W-7W, 2,720 µg/kg at RM 7W-8W, and 123 µg/kg at RM 8W to 9W (Table 5.2-7).

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Commented [KK22R21]: Addition of table reference.

Within the navigation channel, DDx concentrations greater than 100 µg/kg were reported in four samples from three areas RM 5.6 (maximum of 148 µg/kg), RM 6.5 (maximum of 274 µg/kg), and RM 11.3 (maximum of 140 µg/kg). These areas are collocated with contamination present in the adjacent nearshore zones. Mean concentrations in these areas are 12.6 µg/kg at RM 5-6, 29.1 µg/kg at RM 6-7, and 25.2 µg/kg at RM 11-11.8 (Figure 5.2-19, Table 5.2-5).

DDx concentrations greater than 10,000 µg/kg were reported in seven samples, 22 reported values were between 1,000 and 10,000 µg/kg (also located between RM 7.2W and 7.5W, with one result being at RM 8.8), 92 results were between 100 and 1,000 µg/kg, 327 results were between 10 and 100 µg/kg, 636 results were between 1 and 10 µg/kg, and 46 results (four percent) were reported at a concentration less than 1 µg/kg (Tables 5.2-9 and 5.2-10). In all, DDx concentrations greater than 100 µg/kg account for 11 percent of the reported results in surface sediment (Map 5.2-11).

Downstream Reach (RM 0 to 1.9)

DDx was reported in 22 of 25 surface sediment samples within the Downstream reach (frequency of detection 88 percent). Concentrations reported range from 0.2 to 30 µg/kg (Table 5.2-19). DDx was reported at concentrations greater than 10 µg/kg in three samples, 14 results (64 percent) were reported at concentrations between 1 and 10 µg/kg, and five results were reported at concentrations less than 1 µg/kg. The mean DDx concentration in this reach is 5.2 µg/kg (Tables 5.2-19, 5.2-21, and 5.2-22).

5.2.4.2 Total DDx in Subsurface Sediment

Upriver Reach (RM 15.3 to 28.4)

Only three subsurface sediment samples were analyzed for DDx, all between RM 15.4 and 16. DDx was reported in all three samples at concentrations from 4.9 to 9.7 µg/kg, with a mean of 5.8 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

DDx was reported in 64 of 94 subsurface sediment samples within the Downtown reach (frequency of detection 68 percent). Concentrations reported range from 0.05 to 301 µg/kg (Table 5.2-16a), with a mean concentration of 16.3 µg/kg. One result was reported at a concentration greater than 100 µg/kg, 19 results were reported at concentrations between 10 and 100 µg/kg, 32 results were between 1 and 10 µg/kg, 11 results were reported at concentrations less than 1 µg/kg (Tables 5.2-17 and 5.2-18). No subsurface samples were collected in the vicinity of the Zidell facility (Tables 5.2-17 and 5.2-18).

Study Area Reach (RM 1.9 to 11.8)

DDx was reported in 1,393 of 1,678 subsurface samples in the Study Area reach (frequency of detection 83 percent). Concentrations reported range from 0.058 to 1 µg/kg

to 3,643,640,000 µg/kg (Table 5.2-2), the mean concentration is 11,200 µg/kg. The spatial distribution of DDx in the subsurface sediment is presented on Figure 5.2-11 and Maps 5.2-12a-o and 5.2-13a-gg.

Areas in the eastern nearshore zone where DDx is reported at concentrations greater than 100 µg/kg total include a single results at RM ~~52E-63E, from and RM 63.5E-7.5E~~, Swan Island Lagoon, and RM 11E-11.8E. ~~As observed with DDx concentrations in surface sediment,~~ The extent of DDx greater than 100 µg/kg is confined to relatively small area at RM 11E, and more widely dispersed in Swan Island Lagoon (Maps 5.2-12a-o and 5.2-13a-gg). Mean concentrations in these areas in are ~~14.4 µg/kg at RM 1.9E – 3E, 87.1 µg/kg at RM3E-4E, 21.7 µg/kg at RM4E-5E, 56.2 µg/kg at RM 5E-6E, 103 µg/kg at RM 6E-7E, 41.4 µg/kg at RM 7E-8E, 65.1 µg/kg in Swan Island Lagoon, and 464-45.5 µg/kg at RM 11E-11.8E~~ (Figure 5.2-114, Table 5.2-4).

Commented [Int23]: No corresponding observation in surface sediment section.

Commented [KK24R23]: Agree to first part of sentence being removed. Retained second part since it is factually correct.

Areas in the western nearshore zone where DDx concentrations are greater than 100 µg/kg extend from RM 3W through RM ~~910W~~, concentrations greater than 10,000 µg/kg are present between RM ~~6.37W~~ and 7.5W (Map 5.2-11).

Commented [Int25]: Clause does not follow from previous sentence.

The maximum reported subsurface concentration was found in the interval 323 to 384 cm bml at Station WB-24 at RM 7.2E. DDx at concentrations greater than 1,000 µg/kg were reported from ~~RM 7.2W to~~ approximately RM ~~6.51W~~ and RM 8.8W. Mean concentrations in these areas are 39.4 µg/kg at RM 3W-4W, 77.0 µg/kg at RM 4W-5W, 78.4 µg/kg at RM 5W to 6W, 322 µg/kg at RM 6W-7W, 36,900 µg/kg at RM 7W-8W, and 153 µg/kg at RM 8W-9W (Table 5.2-8).

Areas where DDx concentrations are greater than or equal to 100 µg/kg within the navigation channel are located from RM ~~3.24.1~~ to RM 5, RM ~~5.56.4~~ to RM ~~8.47.1~~, and RM ~~409.5~~ to RM 11.5 (Figure 5.2-12a-o14), and generally correspond with contamination found in the adjacent nearshore zones. Mean concentrations in these areas are ~~18 µg/kg at RM 3-4, 74-73.9 µg/kg at RM 4-5, 19.2 µg/kg at RM 5-6, 229 µg/kg at RM 6-7, and 67.1 µg/kg at RM 7-8, 8.87 µg/kg at RM 9-10, 14.6 µg/kg at RM 10-11, and 44-10.8 µg/kg at RM 11-11.8.~~

DDx concentrations greater than 10,000 µg/kg were reported in 51 results, 83 results were between 1,000 and 10,000 µg/kg, 200 results (14 percent of the detected data) were between 100 and 1,000 µg/kg, 489 results (35 percent of the detected data) were between 10 and 100 µg/kg, 425 results (31 percent) were between 1 and 10 µg/kg, and 145 results (ten percent) were reported at a concentration less than 1 µg/kg (Tables 5.2-9 and 5.2-10). DDx concentrations greater than 100 µg/kg account for 24 percent of the detected results.

Downstream Reach (RM 0 to 1.9)

DDx was reported in 17 of 26 subsurface sediment samples within the Downstream reach (frequency of detection 65 percent). Concentrations reported range from 0.28NJ to 80 NJ µg/kg (Table 5.2-20). Reported DDx concentrations between 10 and 100 µg/kg

were reported in 11 results, four were between 1 and 10 µg/kg, and two were reported at a concentration less than 1 µg/kg. The mean concentration in this reach is 19 µg/kg (Tables 5.2-21 and 5.2-22)

5.2.4.3 DDx Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentrations by reach and also by subareas within the Study Area reach. There is insufficient data to compare surface and subsurface concentrations in the Upriver reach. The mean concentration in surface sediment in this reach is 2.01 µg/kg.

Commented [Integral26]: As above, there was no intent to characterize subsurface sediments in upstream reach.

DDx concentrations in the downtown reach are lower in surface sediment than in subsurface sediment. Mean concentrations are 6.66.59 and 16.3 µg/kg in surface and subsurface sediment, respectively.

Within the Study Area, mean DDx concentrations in subsurface sediment is generally higher than in surface sediment (Figure 5.2-12).

Areas where DDx concentrations are greater than 100 µg/kg in subsurface sediment generally align with the locations where surface sediment concentrations are greater than 100 µg/kg (Maps 5.2-11, 5.2-12a-o, and 5.2-13a-gg; Figures 5.2-10, 5.2-11 and 5.2-12). Exceptions occur in the eastern nearshore zone from RM 3 to 5 and RM 7 to 8, the navigation channel from RM 7 to 11, and the western nearshore area from RM 9 to 10 where subsurface concentrations exceed 100 µg/kg, but surface sediment concentrations do not.

Within the downstream reach, DDx concentrations in subsurface sediment concentrations are greater than surface sediment concentrations. Mean concentrations are 5.2 and 19 µg/kg in surface and subsurface sediment, respectively.

5.2.5 Total PAHs in Sediment

Total PAHs is defined as the sum of the individual PAH compound concentrations. The distribution of total PAHs concentrations at each surface sediment sampling station throughout the Study Area is depicted on Map 5.2-14; concentrations with depth at subsurface stations are depicted on Maps 5.2-15a-o. If more than one sample was analyzed at the same surface sediment location, the greater of the two samples is presented on these maps; all subsurface samples are presented. Detailed subsurface sediment chemistry in the Study Area is presented on Maps 5.2-16a-gg.

Figures 5.2-13 and 5.2-14 present scatter plots of the total PAHs data set for surface and subsurface sediment in the Study Area, respectively. The scatter plots present the data in three panels segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-3335).

The summary statistics for total PAHs in the surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2. Summary statistics for surface and

subsurface sediment within the eastern nearshore, navigational channel and western nearshore zones are presented in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Tables 5.2-9 and 5.2-10 present the total PAHs data as orders of magnitude (e.g., <1, 1-10, 10-100, 100-1,000, etc.) for only detected values and for combined detect and nondetect values. Finally, a histogram presenting the average surface and subsurface sediment values by river mile and for the entire Study Area is in Figure 5.2-15.

Data sets for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables. Additionally, the Downtown reach surface sediment samples are presented in Map 5.2-40. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12; number of data points by order of magnitude are provided in Tables 5.2-13 (detect only) and 5.2-14 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downtown reach are shown in Tables 5.2-15 and 5.2-16; number of data points by order of magnitude are provided in Tables 5.2-17 (detect only) and 5.2-18 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20; number of data points by order of magnitude are provided in Tables 5.2-21 (detect only) and 5.2-22 (detect and nondetect).

5.2.5.1 Total PAHs Data Set

Frequencies of detection of PAH compounds were high, approximately 99 percent in surface samples and 95 percent in subsurface samples. The Study Area data set of total PAH concentrations includes 1,661 surface samples and ~~4,545~~1,715 subsurface samples. The Upriver data set includes 78 surface samples and 3 subsurface samples. The downtown data set includes 269 surface samples and 161 subsurface samples. The downstream data set includes 25 surface samples and 26 subsurface samples.

5.2.5.2 Total PAHs in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

Total PAHs were reported in 63 of 78 surface sediment samples within the Upriver reach (frequency of detection 81 percent). Concentrations reported range from 0.91 ~~J~~ to 1,510 µg/kg (Table 5.2-11). Tables 5.2-13 and 5.2-14 show that only one result was reported at a concentration greater than 1,000 µg/kg, 17 (27 percent of the detected data set) were between 100 and 1,000 µg/kg, 39 results (62 percent) were between 10 and 100 µg/kg, 5 were between 1 and 10 µg/kg, and one result was reported at a concentration less than 1 µg/kg. The mean total PAHs concentration in this reach is ~~74~~107 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

Total PAHs were reported in 248 of 269 surface sediment samples within the Downtown reach (frequency of detection 92 percent). Concentrations reported range

from 0.730,0734 to 62,500 µg/kg (Table 5.2-15a), with a mean of 2,174 µg/kg. The spatial distribution of total PAHs in the Downtown reach is presented on Map 5.2-40, reported concentrations greater than 10,000 µg/kg were observed at RM 12.2W, 12.5W, between RM 13.5W and 14W, and at 12.3E.

Total PAHs were reported at a concentration greater than 10,000 µg/kg in 11 results, 55 were between 1,000 and 10,000 µg/kg, 121(49 percent) were between 100 and 1,000 µg/kg, 41 (17 percent) were between 10 and 100 µg/kg, 17 were between 1 and 10 µg/kg, and three results were reported at a concentration less than 1 µg/kg (Tables 5.2-17 and 5.2-18). Within this reach, 27 percent of the detected results were reported at a concentration greater than 1,000 µg/kg.

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. The Zidell data set includes Total PAHs from 112 surface sediment samples (frequency of detection 88 percent). Concentrations reported range from 0.0734 to 32,000 µg/kg, with a mean of 2,538 µg/kg. When the data for the Zidell facility is removed from the downtown data set (Table 5.2-15b), reported total PAHs concentrations in surface sediment range from 0.57J to 62,500 µg/kg, with a mean of 1,940 µg/kg.

Study Area Reach (RM 1.9 to 11.8)

Total PAHs were reported in 1,640 of 1,661 surface sediment samples within the Study Area (frequency of detection 99 percent). Concentrations reported range from 3.30J to 7,260,000 µg/kg (Table 5.2-1). The distribution of reported concentrations varies throughout the Study Area, and is particularly heterogeneous above RM 6.5 where sample density is greater (Figure 5.2-13).

Areas where total PAH concentrations are generally less than 10,000 µg/kg are found in several locations within the Study Area, including the lower end of the Study Area from RM 1.9W to 3W, the upper end of the Study Area from RM 10 to 11.8 (except 3 samples in the eastern nearshore zone), and in the eastern nearshore zone between RM 6E and 10E. The only area in the Navigation Channel with reported concentrations greater than 10,000 µg/kg is from RM 5 to 7 (Figure 5.2-13; Map 5.2-14).

Reported concentrations greater than 1,000 µg/kg are located throughout the Study Area, areas where concentrations -greater than 20,000 µg/kg were encountered in the eastern nearshore zone from RM 4.2E to 4.8E and in the western nearshore zone from RM 5.9W to 6.8W (Figure 5.2-13; Map 5.2-14). The highest reported total PAH concentration in surface sediment of 7,260,000 µg/kg was reported in the navigation channel at RM 6.35.7W (Station G225).

Total PAH concentrations greater than 20,000 µg/kg were also found adjacent to the western nearshore zone in surface sediment in the navigation channel from RM 5.2 to 6.8.

Mean total PAH concentrations by river mile for areas in the eastern nearshore zone with reported concentrations greater than 1,000 µg/kg are 5,160 µg/kg at RM 1.9E-3E, 3,850 µg/kg at RM 3E-4E, 35,100 µg/kg at RM 4E-5E, 5,170 µg/kg at RM 5E-6E, 3,870 µg/kg at RM 6E-7E, 1,420 µg/kg at RM 7E-8E, 3,580 µg/kg in Swan Island Lagoon, 4,850 µg/kg at RM 10E-11E, and 3,640 µg/kg at RM 11E-11.8E (Table 5.2-3).

Mean concentrations by river mile for areas in the western nearshore zone with reported concentrations greater than 1,000 µg/kg are 4,740 µg/kg at RM 3W-4W, 7,940 µg/kg at RM 4W-5W, 17,300 µg/kg at RM 5W-6W, 192,000 µg/kg at RM 6W-7W, 3,490 µg/kg at RM 7W-8W, 2,280 µg/kg at RM 8W-9W; and 2,510 µg/kg at RM 9W-10W (Table 5.2-7).

Mean total PAH concentrations by river mile in the navigation channel for areas where concentrations are greater than 1,000 µg/kg are 275,000 µg/kg at RM 5-6 and 58,600 µg/kg at RM 6-7 (Table 5.2-5).

Total PAH concentrations greater than 10,000 µg/kg were reported in 233 results, 636 were between 1,000 and 10,000 µg/kg, 661 were between 100 and 1,000 µg/kg, 104 were between 10 and 100 µg/kg, and six results were reported at concentrations ranging from 1 to 10 µg/kg (Tables 5.2-9 and 5.2-10). Fifty-five percent of the results within the Study Area were reported at concentrations greater than 1,000 µg/kg (Map 5.2-14).

Downstream Reach (RM 0 to 1.9)

Total PAHs were reported in 25 of 25 surface sediment samples within the Downstream reach. Concentrations reported range from 1.4J µg/kg to 18,000J µg/kg (Table 5.2-19). One result was reported at a concentration greater than 10,000 µg/kg, one was between 1,000 and 10,000 µg/kg, 16 were between 100 and 1,000 µg/kg, six were between 10 and 100 µg/kg, and one result was between 1 and 10 µg/kg (Tables 5.2-21 and 5.2-22). The mean total PAHs concentration in this reach is 1,120 µg/kg.

5.2.5.3 Total PAHs in Subsurface Sediment

Upriver Reach (RM 15.3 to 28.4)

Total PAHs were reported in three of three samples collected between RM 15.4 and 16. Concentrations reported range from 253 µg/kg to 533 µg/kg, with a mean of 366 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

Total PAHs were reported in 157 of 161 subsurface sediment samples within the Downtown reach (frequency of detection 98 percent). Concentrations reported range from 0.25J to 4,850,000 µg/kg (Table 5.2-16a), with a mean of ~~235,000~~219,700 µg/kg.

Total PAH concentrations greater than 10,000 µg/kg were reported in 30 results, 39 results were between 1,000 and 10,000 µg/kg, 52 results were between 100 and 1,000 µg/kg, 23 results were between 10 and 100 µg/kg, six were between 1 and 10 µg/kg, and seven results were reported at concentrations less than 1 µg/kg (Tables 5.2-17 and 5.2-18). Within this reach, reported concentrations greater than 1,000 µg/kg account for 44 percent of the detected results, with the highest concentrations observed in the western nearshore area at RM 12.2 (Figure 5.2-14).

Twelve of the subsurface samples were collected in the vicinity of the Zidell facility, reported concentrations ranged from 4.8 to 451 µg/kg. With these values excluded, the mean and median total PAH concentrations are 235,000 and 770 µg/kg, respectively.

Study Area Reach (RM 1.9 to 11.8)

Total PAHs were reported in 1,643 of 1,715 subsurface samples (frequency of detection 96 percent). Concentrations reported range from 0.150 J µg/kg to 53,300,000 µg/kg (Table 5.2-2).

Areas where total PAH concentrations exceeded 10,000 µg/kg were observed in the eastern nearshore zone between RM 3.5E and 7.5E, in Swan Island Lagoon, and at RM 11.2E. Mean concentrations by river mile in these areas are 22,000 µg/kg at RM 3E-4E, 23,500 µg/kg at RM 4E-5E, 11,600 µg/kg at RM 5E-6E, 6,560 µg/kg for RM 6E-7E, 3,010 µg/kg at RM 7E-8E, ~~and~~ 3,400 µg/kg in Swan Island Lagoon, and 2,790 µg/kg for RM 11E-11.8E (Table 5.2-4).

Locations in the western nearshore where total PAHs concentrations greater than 10,000 µg/kg are observed include RM 3W to 7.5W and at RM 9.2W (Figure 5.2-14, Maps 5.2-15a-0 and 5.2-16a-gg). The highest concentrations in subsurface sediment are found between RM 6W and 6.5W, the highest reported value of 53,300,000 µg/kg was observed in this area at Station C302. Mean concentrations by river mile in these areas are 19,000 µg/kg at RM 3W-4W, 24,700 µg/kg at RM 4W-5W, 45,400 µg/kg at RM 5W-6W, 1,610,000 µg/kg at RM 6W-7W, 3,560 µg/kg at RM 7W-8W, and 19,200 µg/kg for RM 9W-10W (Table 5.2-8).

Total PAH concentrations greater than 10,000 µg/kg were also observed in subsurface sediment in the navigation channel from RM 4 to 6.5, adjacent to and downstream from the high concentration area in the western nearshore zone between RM 6 and 6.5 and at RM 7.9. Mean concentration by river mile in this area are. 5,240 µg/kg at RM 4-5, 8,450 µg/kg at RM 5-6, ~~and~~ 453,000 µg/kg at RM 6-7, and 1,350 µg/kg at RM 7-8 (Table 5.2-6).

Within the Study Area, total PAH concentrations greater than 10,000 µg/kg were reported in 335 results, 563 were between 1,000 and 10,000 µg/kg, 484 were reported at concentrations between 100 and 1,000 µg/kg, 137 were detected at concentrations between 10 and 100 µg/kg, 87 were between 1 and 10 µg/kg, and 37 results were reported at concentrations less than 1 µg/kg. Concentrations greater than 1,000 µg/kg

account 54 percent of the reported results within the Study Area (Tables 5.2-9 and 5.2-10)

Downstream Reach (RM 0 to 1.9)

Total PAHs were reported in all 26 subsurface sediment samples collected within the Downstream reach. Concentrations reported range from 0.49J to 23,000 µg/kg (Table 5.2-20). Tables 5.2-21 and 5.2-22 show that one result was reported at a concentration greater than 10,000 µg/kg, four were between 1,000 and 10,000 µg/kg, 10 were between 100 and 1,000 µg/kg, seven results were reported at concentrations between 10 and 100 µg/kg, two were between 1 and 10 µg/kg, and two results were reported at a concentration less than 1 µg/kg. Within the Downstream Reach, reported concentrations greater than 1,000 µg/kg account for 19 percent of the reported results in subsurface sediment. The mean total PAH concentration in the Downstream Reach is ~~1,340~~1,339 µg/kg.

5.2.5.4 Total PAHs Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentrations by reach and also by subareas within the Study Area reach.

There are insufficient data to compare surface and subsurface concentrations in the Upriver reach. The mean surface sediment total PAH concentration in this reach is

Commented [Integral27]: As above.

Total PAH concentrations within the Downtown reach are greater in subsurface sediment relative to concentrations observed in surface sediment. Mean concentrations are 2,174 and 219,700 µg/kg in surface and subsurface sediment, respectively.

Within the Study Area, total PAH concentrations are generally greater in subsurface than in surface sediments. Mean concentrations in surface and subsurface sediments are 27,200 and ~~249,000~~246,000 µg/kg (Tables 5.2-1 and 5.2-2). Localized areas where concentrations are greater in surface sediment are found from RM 1.9E to 3E, RM 4E to 5E, Swan Island Lagoon, and RM 10E to 11.8E within the eastern nearshore zone, except RM 8W to 9W in the western nearshore zone, and RM 5 to 6, RM 8 to 9, and RM 9 to 10 within the navigation channel.

Areas with the highest reported total PAH concentrations in both surface and subsurface sediment generally align (Maps 5.2-15a-o and 5.2-16a-gg and Figures 5.2-13, 5.2-14, and 5.2-15).

Within the downstream reach total PAH concentrations are greater subsurface than in surface sediment, Mean concentrations are 1,120 and ~~1,340~~1,339 µg/kg in surface and subsurface sediment, respectively.

5.2.6 Bis(2-ethylhexyl)phthalate in Sediment

The distribution of BEHP concentrations at each surface sediment sampling station throughout the Study Area is depicted on Map 5.2-17; concentrations with depth at subsurface stations are depicted on Maps 5.2-18a-o. If more than one sample was analyzed at the same surface sediment location, the greater of the two samples is presented on these maps; all subsurface samples are presented.

Figures 5.2-16 and 5.2-17 present scatter plots of the BEHP data set for surface and subsurface sediment in the Study Area, respectively. The scatter plots present the data in three panels segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-33).

The summary statistics for BEHP in surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2. Summary statistics for surface and subsurface sediment within the eastern nearshore, navigation channel, and western nearshore zones are presented in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Tables 5.2-9 and 5.2-10 present BEHP data as orders of magnitude (e.g., <1, 1-10, 10-100, 100-1,000, etc.) for only detected values and for combined detected and nondetect values. Finally, a histogram presenting the average surface and subsurface sediment values by river mile and for the entire Study Area is in Figure 5.2-18.

Data sets for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables. Additionally, the Downtown reach surface sediment samples are presented in Map 5.2-41. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12; number of data points by order of magnitude are provided in Tables 5.2-13 (detect only) and 5.2-14 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downtown reach are shown in Tables 5.2-15 and 5.2-16; number of data points by order of magnitude are provided in Tables 5.2-17 (detect only) and 5.2-18 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20; number of data points by order of magnitude are provided in Tables 5.2-21 (detect only) and 5.2-22 (detect and nondetect).

5.2.6.1 BEHP Data Set

The Study Area data set of BEHP concentrations includes 1,513 surface and 1,591 subsurface samples, the Upriver data set includes 72 surface and 3 subsurface samples, the downtown data set includes 96 surface samples and 64 subsurface samples, and the downstream data set includes 21 surface and 17 subsurface samples. Because the reporting limit for several nondetect results were greater than the maximum reported values (Figures 5.2-16 and 5.2-17), thus, the majority of this discussion will focus on detected values.

5.2.6.2 BEHP in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

BEHP was reported in 56 of 72 surface sediment samples and within the Upriver reach (frequency of detection 78 percent). Concentrations reported range from 4.2J to 2,100 µg/kg (Table 5.2-11). One result was reported at a concentration greater than 1,000 µg/kg, nine were between 100 to 1,000 µg/kg, 40 results were between 10 and 100 µg/kg, and six were between 1 and 10 µg/kg (Tables 5.2-13 and 5.2-14). The mean BEHP concentration in this reach is 94 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

BEHP was reported in 78 of 96 surface sediment samples within the Downtown reach (frequency of detection 81 percent). Concentrations reported range from 7.6J to 18,000 µg/kg (Table 5.2-15a), with a mean of 418 µg/kg. The spatial distribution of BEHP in surface sediment is presented on Map 5.2-41.

Within the Downtown reach, one result was reported at a concentration greater than 10,000 µg/kg, one result was between 1,000 and 10,000 µg/kg, 32 were between 100 and 1,000, 39 were between 10 and 100 µg/kg, and 5 results were reported at concentrations between 1 and 10 µg/kg (Tables 5.2-17 and 5.2-18).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. None of the BEHP data was excluded from the Downtown reach.

Study Area Reach (RM 1.9 to 11.8)

BEHP was reported in 932 of 1,513 surface sediment samples within the Study Area (frequency of detection 62 percent). Concentrations reported range from 7.00J to 440,000J µg/kg (Table 5.2-1), with a mean of 1,050 µg/kg. The spatial distribution of BEHP in surface sediment is presented on Figure 5.2-16.

Areas where BEHP concentrations are greater than 1,000 µg/kg were observed in the eastern nearshore zone between RM 3.8E and 4.1E and in the International Terminals Slip, Swan Island Lagoon, RM 7E and 8E and at RM 11.2E (Figure 5.2-16, Map 5.2-17). The highest reported surface concentration in the Study Area of 440,000J µg/kg was found at Station G367 at the mouth of Swan Island Lagoon. Mean BEHP concentrations by river mile in these areas are 1,310 µg/kg at RM 3E-4E, 792 µg/kg at RM 4E-5E, 573 µg/kg at RM 7E-8E; 6,150 µg/kg in Swan Island Lagoon, and 204 µg/kg at RM 11E-11.8E (Table 5.2-3)

BEHP concentrations greater than 1,000 µg/kg were observed in the western nearshore zone from RM 6W through 10W, with a prominent peak at RM 8.8W (Figure 5.2-16).

Mean concentrations by river mile are 256 µg/kg at RM 6W-7W, 347 at RM 7W-8W, 745 µg/kg at RM 8W-9W, and 531 µg/kg at RM 9W-10W (Table 5.2-7).

The greatest concentrations observed in the navigation channel zone are located near RM 10 (Map 5.2-17). Additional elevated concentrations are located at RM 5.2, Swan Island Lagoon, and RM 10.3 in the western nearshore area (Map 5.2-17). Mean concentrations in these areas are 203 µg/kg at RM 5-6, 679 µg/kg in Swan Island Lagoon, and 446 µg/kg at RM 10-11 (Table 5.2-5).

Commented [Int28]: Source statement, present in Section 10.

BEHP concentrations greater than 10,000 µg/kg were reported in nine results, 79 were between 1,000 and 10,000 µg/kg, 501 (54 percent of the detected results) were reported at concentrations between 100 and 1,000 µg/kg, 336 were between 10 to 100 µg/kg, and seven results were reported at concentrations between 1 and 10 µg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

BEHP was reported in 10 of 21 surface sediment samples within the Downstream reach (frequency of detection 48 percent). Concentrations reported from 7.1 J µg/kg to 170 µg/kg (Table 5.2-19). Two results were reported at a concentration greater than 100 µg/kg, seven were between 10 and 100 µg/kg, and one result was less than 10 µg/kg. The mean BEHP concentration in this reach is 64 µg/kg (Tables 5.2-21 and 5.2-22).

5.2.6.3 BEHP in Subsurface Sediment

Upriver Reach (RM 15.3 to 26)

Three subsurface sediment samples were collected and analyzed for BEHP between RM 15.4 and 16. BEHP was reported in all three samples, concentrations reported range from 20 J to 3,800 µg/kg, with a mean of 1,300 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

BEHP was reported in 36 of 64 subsurface sediment samples within the Downtown reach (frequency of detection 56 percent). Concentrations reported range from 2.5 J to 815 µg/kg with a mean of 103 µg/kg (Table 5.2-16a). Eight results were reported at concentrations greater than 100 µg/kg, 23 results were between 1 and 10 µg/kg, and five results were reported at a concentration less than 10 µg/kg (Table 5.2-17). None of the subsurface samples were collected in the vicinity of the Zidell facility.

Study Area Reach (RM 1.9 to 11.8)

Within the Study Area, BEHP was reported in 635 of 1,591 subsurface samples (frequency of detection 40 percent). Concentrations reported range from 2.40 J to 18,000 µg/kg (Table 5.2-2), with a mean of 345 µg/kg. The spatial distribution of BEHP concentrations in subsurface sediment are presented on Figure 5.2-17 and Maps 5.2-18a-o.

Table 5.2-9 shows that there are two data points greater than 10,000 µg/kg. There are 32 detected values between 1,000 and 10,000 µg/kg, which are primarily located within

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the peak areas discussed above. Subsurface sediment samples greater than 1,000 µg/kg accounts for five percent of the detected data set. An additional 257 samples, 40 percent of the detected data set, were detected at concentrations between 100 and 1,000 µg/kg. Half of the detected data set (317 samples) is between 10 and 100 µg/kg. An additional 27 samples (four percent) are comprised of concentrations ranging between 1 and 10 µg/kg and there were no samples detected at a concentration less than 1 µg/kg.

Areas where BEHP concentrations greater than 1,000 µg/kg are observed in subsurface sediment are present in the eastern nearshore between RM 3.6 and 4.4 and in the International Terminals Slip, and in Swan Island Lagoon (Figure 5.2-17, Map 5.2-18). Mean concentrations (Table 5.2-3) in these areas are 586 µg/kg at RM 3E-4E, 23,500 µg/kg at RM 4E-5E, and 650 µg/kg in Swan Island Lagoon.

Areas in the western nearshore zone where BEHP concentrations are greater than 1,000 µg/kg are observed from RM 6 through 10 (Figure 5.2-17 and Maps 5.2-18g,h,j,k). Mean concentrations by river mile in this area are 338 µg/kg at RM 6W-7W, 277 at RM 7W-8W, 628 µg/kg at RM 8W-9W, and 359 µg/kg at RM 9W-10W (Table 5.2-6).

~~The maximum reported concentration of 18,000 µg/kg in subsurface sediment was from the navigation channel, from the interval of 0–195 cm bml at Station WR-VC-110 (RM 10.3).~~ Within the navigation channel the highest concentrations greater than 1,000 µg/kg of BEHP are observed at RM 7.9 (which appears most likely associated the reported concentrations in Swan Island Lagoon, Map 5.2-18i), and a single result at RM 10.3 near the western nearshore area (Map 5.2-18i). Mean BEHP concentrations in these areas are: 910 µg/kg for RM 7 to 8; and 502 µg/kg for RM 10 to 11 (Table 5.2-6). ~~The maximum reported concentration of 18,000 µg/kg in subsurface sediment was from the navigation channel, from the interval of 0–195 cm bml at Station WR-VC-110 (RM 10.3).~~

Downstream Reach (RM 0 to 1.9)

BEHP was reported in 16 of 17 subsurface sediment samples less within the Downstream reach (frequency of detection 94 percent). Concentrations reported range from 3.1 µg/kg to 39 µg/kg (Table 5.2-20). Five results were reported at concentrations greater than 10 µg/kg and eleven were less than 10 µg/kg. The mean concentration in this reach is 8.2 µg/kg (Tables 5.2-21 and 5.2-22).

5.2.6.4 BEHP Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentrations by reach and also by subareas within the Study Area reach.

There are insufficient data to compare surface and subsurface concentrations in the Upriver reach. The mean BEHP surface sediment concentration in this reach is 94 µg/kg.

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The surface BEHP sediment concentrations in the downtown reach are greater than the subsurface concentrations, and are 418 and 103 µg/kg, respectively.

Within the Study Area BEHP concentrations are generally greater in surface than in subsurface sediments, mean concentration are 1,050 and 345 µg/kg in surface and subsurface sediment, respectively (Tables 5.2-1 and 5.2-2). Exceptions to this general trend are observed in the eastern nearshore zone at RM 5E-6E where mean surface and subsurface concentrations are similar, and RM 8E-9E where the mean concentration in subsurface sediment is approximately twice that surface sediment (Tables 5.2-3 and 5.2-4). The maximum BEHP concentrations in surface and subsurface sediment in the eastern nearshore zone are both found in Swan Island Lagoon.

Within the western nearshore zone, localized areas where BEHP concentrations are greater in subsurface sediment include RM 5W-6W, where the mean subsurface concentration is an order of magnitude greater than the mean surface concentration, and RM 7W-8W, where mean surface and subsurface concentrations are similar. The maximum reported BEHP concentration in surface sediment in the western nearshore zone was located between RM 7W and 8W, while the maximum reported concentration in subsurface sediment was located between RM 5W and 6W.

Within the navigation channel, the mean BEHP concentration in subsurface sediment at RM 7 to 8 is approximately three times the mean surface. The maximum reported surface and subsurface BEHP concentration in the navigation channel were reported at RM 10 to 11.

Within the downstream reach, mean BEHP concentrations are greater in surface sediment (64 and 11 µg/kg in surface and subsurface sediment, respectively).

5.2.85.2.7 Total Chlordanes in Sediment

The distribution of total chlordanes concentrations at each surface sediment sampling station throughout the Study Area is depicted on Map 5.2-19; concentrations with depth at subsurface stations are depicted on Maps 5.2-20a-o. If more than one sample was analyzed at the same surface sediment location, the greater of the two samples is presented on these maps; all subsurface samples are presented.

Figures 5.2-19 and 5.2-20 present scatter plots of the total chlordanes data set for surface and subsurface sediment in the Study Area, respectively. The scatter plots present the data in three panels segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-3335).

Summary statistics for total chlordanes in surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2, surface and subsurface sediment within the eastern nearshore, navigation channel, and western nearshore zones in Tables

5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Tables 5.2-9 and 5.2-10 present total chlordanes data by orders of magnitude (e.g., <1, 1-10, 10-100, 100-1,000, etc.) for detected-only values and for combined detected and nondetect values. Finally, a histogram presenting the average surface and subsurface sediment values by river mile and for the entire Study Area is in Figure 5.2-217.

Data sets for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables. Additionally, the Downtown reach surface sediment samples are presented in Map 5.2-42. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12; number of data points by order of magnitude are provided in Tables 5.2-13 (detects only) and 5.2-14 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downtown reach are shown in Tables 5.2-15 and 5.2-16; number of data points by order of magnitude are provided in Tables 5.2-17 (detects only) and 5.2-18 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20; number of data points by order of magnitude are provided in Tables 5.2-21 (detects only) and 5.2-22 (detects and nondetects).

5.2-8-15.2.7.1 Total Chlordanes Data Set

The Study Area data set of total chlordanes concentrations includes 1,193 surface and 1,214 subsurface samples, the Upriver data set includes 77 surface and 3 subsurface samples, the downtown data set includes 145 surface and 94 subsurface samples, and the downstream data set includes 25 surface and 26 subsurface samples. Several nondetect results had reporting limits greater than the maximum reported concentrations (Figures 5.2-19 and 5.2-20), thus the majority of this discussion will focus on the detected values only as meaningful conclusions cannot be drawn from the elevated nondetected values.

5.2-8-25.2.7.2 Total Chlordanes in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

Total chlordanes were detected in 38 of 77 surface sediment samples within the Upriver reach (frequency of detection 49 percent). Concentrations reported range from 0.040.057 J to 1.53 µg/kg (Table 5.2-11). Two results were reported at a concentration greater than 1 µg/kg, the remaining 36 detections were all reported at concentrations less than 1 µg/kg (Table 5.2-13). The mean concentration in this reach is 0.391 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

Total chlordanes were reported in 110 of 145 surface sediment samples within the Downtown reach (frequency of detection 76 percent). Concentrations reported range from 0.040.039 J to 23.2 J µg/kg (Table 5.2-15a), the mean concentration is 1.31.29 µg/kg. The spatial distribution of total chlordanes in surface sediment within the Downtown reach is shown on Map 5.2-42.

Within the Downtown reach, total chlordane was reported at a concentration greater than 10 µg/kg in two results, 35 were between 1 and 10 µg/kg, and 73 results were reported at concentrations less than 1 µg/kg (Table 5.2-17).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. None of the total chlordanes data was excluded from the Downtown reach.

Study Area Reach (RM 1.9 to 11.8)

Total chlordanes were reported in 761 of 1,193 surface sediment samples within the Study Area (frequency of detection 64 percent). Concentrations reported range from 0.03 µg/kg to 669 µg/kg (Table 5.2-1), with a mean concentration in surface sediment of 5.03 µg/kg. The spatial distribution of reported chlordane concentrations in surface sediment within the Study Area is presented on Figure 5.2-19.

Areas in the eastern nearshore zone where reported concentrations greater than 10 µg/kg are reported were observed at RM 2.8E, RM 3.8E, RM 5.5E, Swan Island Lagoon, and RM 11E (Figure 5.2-19 and Map 5.2-19). The highest surface concentration detected in the eastern nearshore zone (60 µg/kg) was found at Station GCA11E at RM 11E. Mean concentrations in these areas are 1.15 µg/kg at RM 2E-3E, 1.48 µg/kg at RM 3E-4E, 2.37 µg/kg at RM 5E-6E, 2.75 µg/kg in Swan Island Lagoon, and 11.4 µg/kg at RM 11E -11.8E (Table 5.2-3).

Areas in the western nearshore zone were reported total chlordane concentrations greater than 10 µg/kg were observed from RM 5.8W through 9W (Figure 5.2-19). The maximum reported concentration in surface sediment of 669 µg/kg was at Station G355 (RM 7.3W). Mean concentrations in the western nearshore zone are 1.75 µg/kg at RM 5W-6W, 12.5 µg/kg at RM 6W-7W, 24.9 µg/kg at RM 7W-8W, and 28.9 µg/kg at RM 8W-9W. Within the navigation channel there were no reported concentrations greater than 10 µg/kg (Table 5.2-75).

Table 5.2-9 shows that there are three detected data points in surface sediment Total chlordane concentrations greater than 100 µg/kg were reported in three results, 46 were between 10 and 100 µg/kg, 270 detected results were between 1 and 10 µg/kg, and 442 results (58 percent of detections) were reported at concentrations less than 1 µg/kg.

Downstream Reach (RM 0 to 1.9)

Total chlordanes were reported in 15 of 25 surface sediment samples within the Downstream reach (frequency of detection 60 percent). Concentrations reported range from 0.07 µg/kg to 4.5 µg/kg (Table 5.2-19). Three results were reported at a concentration greater than 1 µg/kg, the remaining 12 results were all less than 1 µg/kg (Table 5.2-21), with a mean of 0.81 µg/kg.

5.2.8.35.2.7.3 Total Chlordanes in Subsurface Sediment

Upriver Reach (RM 15.3 to 26)

Only three subsurface sediment samples were analyzed for total chlordane in the upriver reach, all collected between RM 15.4 and 16. Chlordanes were reported in all three results, from ~~0.20~~1.87 to ~~4.32~~9.93 µg/kg, with a mean of ~~0.89~~1.34 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

Total chlordanes were reported in 51 of 94 subsurface sediment samples within the Downtown reach (frequency of detection 54 percent). Concentrations reported range from 0.09~~4~~J to 54~~J~~J µg/kg (Table 5.2-16a), with a mean concentration of ~~3.23~~16 µg/kg. There are two values detected above 10 µg/kg. Total chlordane was reported at concentrations between 1 and 10 µg/kg in 26 results, the remaining 23 results were reported at concentrations less than 1 µg/kg (Table 5.2-17). ~~No~~ subsurface samples were collected from the vicinity of the Zidell facility.

Study Area Reach (RM 1.9 to 11.8)

Total chlordanes were reported in 648 of 1,214 subsurface samples (frequency of detection 53 percent) within the Study Area. Concentrations reported range from ~~0.040~~0.0390~~J~~ to 2,330~~J~~ µg/kg (Table 5.2-2), with a mean concentration of ~~20~~19.5 µg/kg. The spatial distribution of total chlordane in subsurface sediment is presented on Figure 5.2-20 and Maps 5.2-20a-o.

Areas in the eastern nearshore zone where total chlordane in subsurface sediment was reported at concentrations greater than 10 µg/kg were observed at RM 2.2E, RM 3.8E, RM 5.5E, Swan Island Lagoon, at RM 11E (Figure 5.2-20 and Map 5.2-20a-o). The highest total chlordane concentration of 490 µg/kg in subsurface sediment reported in the eastern nearshore zone was at Station C092 at RM 3.8E. Mean total chlordane concentrations by river mile are 2.26 µg/kg at RM 2E-3E, 31.2 µg/kg at RM 3 E-4E, 4.67 µg/kg at RM 5E-6E, 15.5 µg/kg in Swan Island Lagoon, and 23.5 µg/kg for RM 11E-11.8E (Table 5.2-3).

Total chlordane concentrations greater than 10 µg/kg in the western nearshore zone from RM 4.5~~W~~ through 9~~W~~. The highest reported total chlordane concentration of 2,330~~J~~ µg/kg in subsurface sediments was reported at RM 8.8~~W~~ at Station C455 in the interval of 30–152 cm bml (Figure 5.2-20). Mean concentrations 5.79 µg/kg for RM 4W-5W, 17.2 µg/kg at RM 5W-6W, 18.9 µg/kg at RM 6W-7W, 68.5 µg/kg at RM 7E-8E, 61.4 µg/kg at RM 8E-9E (Table 5.2-8).

The highest reported concentrations of chlordane in subsurface sediment in the navigation channel were observed RMs 6.5, 10.3 and 11.3. Chlordane concentrations at RM 6.5 appear associated with observed contamination in the western nearshore zone (Map 5.2-20g), concentrations at RM 11.3 are ~~most likely~~potentially associated the contamination noted at RM 11E (Maps 5.2-20n,o). Mean concentrations are ~~1.94~~6.59 µg/kg at RM 6-7, 2.83 µg/kg for RM 10-11, and 7.82 at RM 11-11.8 (Table 5.2-6).

Total chlordane was reported at a concentration greater than 1,000 µg/kg in one result, 19 were between 100 and 1,000 µg/kg, 67 results were reported at concentrations between 10 and 100 µg/kg, 316 were between 1 and 10 µg/kg, and 245 results were reported at concentrations less than 1 µg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Total chlordanes were reported in 5 of 26 subsurface sediment samples within the Downstream reach (frequency of detection 19 percent). Concentrations reported range from 0.75 NJ to 2.2 NJ µg/kg (Table 5.2-20). Four results were reported at a concentration greater than 1 µg/kg and one sample was reported at less than 1 µg/kg, with a mean in of 1.5 µg/kg (Tables 5.2-21).

5.2.8.45.2.7.4 Total Chlordanes Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentrations by reach and also by subareas with the Study Area reach. There is insufficient data to compare surface and subsurface concentrations in the Upriver reach. The mean total chlordanes surface sediment concentration in this reach is 0.391 µg/kg (Table 5.2-11).

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Within the downtown reach the mean total chlordane concentration in surface sediment is 4.31.29 µg/kg and 3.23.16 µg/kg subsurface sediment (Tables 5.2-15a and 5.2-16a).

Within the Study Area, total chlordane concentrations are greater in the subsurface sediments. The mean concentration in surface and subsurface sediments is 5.03 and 2019.5 µg/kg, respectively (Tables 5.2-1 and 5.2-2). As shown on Figure 5.2-21, mean concentrations are greater in the nearshore areas than in the navigation channel, and the western nearshore zone is greater than the eastern nearshore zone.

In the eastern nearshore zone, total chlordane concentrations are greater in subsurface than in surface sediment in all river mile except RM 10 to 11. In the western nearshore zone, subsurface sediment concentrations are greater in all river miles except RM 1.9 to 3. Within the navigation channel total chlordane in subsurface sediment is greater than the surface sediment concentrations except from RM 1.9 to RM 4. Areas where the highest chlordane concentrations are observed generally align between surface and subsurface sediment.

Within the downstream reach, the mean total chlordane concentrations are 0.812 µg/kg and 1.5 µg/kg in surface and subsurface sediment, respectively (Tables 5.2-19 and 5.2-20).

5.2.95.2.8 Aldrin and Dieldrin in Sediment

The insecticides aldrin and dieldrin, have similar chemical structures and are discussed together here because aldrin readily undergoes biotic and abiotic transformation to

dieldrin. However, because aldrin is not converted to dieldrin under anaerobic conditions, it is unlikely that aldrin is converted to dieldrin in sediments but may do so within other media that will be discussed in subsequent sections.

The distribution of aldrin and dieldrin concentrations at each surface sediment sampling station throughout the Study Area is depicted on Maps 5.2-21 and 5.2-23; concentrations with depth at subsurface stations are depicted on Maps 5.2-22a-o and 5.2-24a-o. If more than one sample was analyzed at the same surface sediment location, the greater of the two results is presented on these maps; all subsurface samples are presented.

Figures 5.2-22 and 5.2-23 present scatter plots of the aldrin data set for surface and subsurface sediment in the Study Area, respectively. Figures 5.2-25 and 5.2-26 present scatter plots of the dieldrin data set for surface and subsurface sediment in the Study Area, respectively. The scatter plots present the data in three panels segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-~~33~~35).

The summary statistics for aldrin and dieldrin in surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2. Summary statistics for surface and subsurface sediment within the eastern nearshore, navigation channel, and western nearshore zones are presented in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Tables 5.2-9 and 5.2-10 present aldrin and dieldrin results as orders of magnitude (e.g., <1, 1-10, 10-100, 100-1,000, etc.) for only detected values and for combined detected and nondetect values. Finally, a histogram presenting the average surface and subsurface sediment values by river mile and for the entire Study Area is in Figures 5.2-24 (for aldrin) and 5.2-27 (for dieldrin).

Data sets for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables. Additionally, the Downtown reach surface sediment samples are presented in Maps 5.2-43 and 5.2-44. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12; number of data points by order of magnitude are provided in Tables 5.2-13 (detects only) and 5.2-14 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downtown reach are shown in Tables 5.2-15 and 5.2-16; number of data points by order of magnitude are provided in Tables 5.2-17 (detects only) and 5.2-18 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20; number of data points by order of magnitude are provided in Tables 5.2-21 (detects only) and 5.2-22 (detects and nondetects).

5.2-9.15.2.8.1 Aldrin and Dieldrin Data Sets

The Study Area data set for aldrin consists of 1,146 surface and 1,272 subsurface samples, 77 surface and 3 subsurface samples from the Upriver reach, 145 surface and 94 subsurface samples from the downtown reach, and 25 surface and 26 subsurface samples from the downstream reach.

The Study Area data set for dieldrin consists of 1,190 surface and 1,208 subsurface samples, 77 surface and 3 subsurface samples from the Upriver reach, 145 surface and 94 subsurface samples from the downtown reach, and 25 surface and 26 subsurface samples from the downstream reach.

~~Data quality issues resulted in~~ There were high detection limits for several aldrin and dieldrin results within the Study Area (Figures 5.2-22 and 5.2-23 for aldrin, Figures 5.2-25 and 5.2-26 for dieldrin); thus, the majority of this discussion, as for other contaminants, will focus on the detected values only since meaningful conclusions cannot be drawn from the elevated nondetect values.

5.2.9.25.2.8.2 Aldrin and Dieldrin in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

Aldrin was reported in seven of 77 surface sediment samples within the Upriver reach (detection frequency of nine percent). Concentrations reported range from 0.17 J to 0.55 µg/kg (Table 5.2-11, Table 5.2-13) with a mean concentration of 0.334 µg/kg.

Dieldrin was reported in 10 of 77 surface sediment samples (frequency of detection 13 percent), concentrations reported range from 0.092 NJ to 0.4 µg/kg (Table 5.2-11, Table 5.2-13) with a mean concentration of 0.209 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

Aldrin was reported in 22 of 145 surface sediment samples within the Downtown reach (frequency of detection 15 percent). Concentrations reported range from 0.0735 J to 0.7 NJ µg/kg (Table 5.2-15a, Table 5.2-17) with a mean concentration of 0.262 µg/kg.

Dieldrin was reported in 14 of 145 surface sediment within the Downtown reach (frequency of detection ten percent). Concentrations reported range from 0.042 J to 1.1 µg/kg (Table 5.2-15a, Table 5.2-17) with a mean concentration of 0.266 µg/kg.

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. None of the aldrin or dieldrin data was excluded from the Downtown reach.

Study Area Reach (RM 1.9 to 11.8)

Aldrin was reported in 268 of 1,146 surface sediment samples within the Study Area (frequency of detection 23 percent). Concentrations reported range from 0.00333 J to 691 J µg/kg (Table 5.2-1), with a mean concentration of 54.89 µg/kg. The spatial distribution of aldrin in surface sediment in the Study Area is presented on Figure 5.2-22.

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Dieldrin was reported in 252 of 1,190 surface sediment samples within the Study Area (frequency of detection 21 percent). Concentrations reported range from 0.008~~34~~J to 356~~J~~J µg/kg (Table 5.2-1) with a mean concentration of ~~32.56~~J µg/kg. The spatial distribution of dieldrin in surface sediment is presented on Figure 5.2-25.

Aldrin was not reported at a concentration greater than 10 µg/kg in surface sediment within the eastern nearshore zone (Figure 5.2-22), areas were reported concentrations greater than 1 µg/kg are noted in the eastern nearshore zone from RM ~~2E~~E to ~~4E~~E, RM ~~5.8E~~E to ~~6.2E~~E, and in Swan Island Lagoon. The highest reported concentration in surface sediment of 6 µg/kg aldrin in the eastern nearshore zone was at Station PSY01 in Swan Island Lagoon. Mean aldrin concentrations (Table 5.2-3) for these areas in the eastern nearshore zone are ~~0.90.872~~J µg/kg at RM 1.9E-3E, 0.5~~17~~J µg/kg at RM 3E-4E, 0.899 µg/kg at RM 5E-6E, and 1.03 µg/kg in Swan Island Lagoon.

Detected concentrations of dieldrin greater than 10 µg/kg in surface sediment were observed only in Swan Island Lagoon (Figure 5.2-25). Concentrations greater than 1 µg/kg were observed in the same pattern as aldrin, with the addition of RM ~~11E~~E to ~~11.8E~~E in the eastern nearshore zone. The highest reported concentration of dieldrin in surface sediment in the eastern nearshore zone (22 µg/kg) is located at Station M0201 in Swan Island Lagoon. Mean concentrations of dieldrin (Table 5.2-3) in these areas in the eastern nearshore zone are 0.8~~26~~J µg/kg at RM 1.9E-3E, 0.2~~05~~J µg/kg at RM 3E-4E, ~~4.21.17~~J µg/kg at RM 5E-6E, 4.35 µg/kg in Swan Island Lagoon, and ~~4.44.38~~J µg/kg at RM ~~11E-11.8E~~E.

Aldrin at concentrations greater than 10 µg/kg was reported in the western nearshore zone in from RM ~~6.8W~~W through ~~7.2W~~W and at RM ~~8.8W~~W. Reported concentrations greater than 100 µg/kg were observed at RMs ~~7.3W~~W and ~~8.8W~~W (Figure 5.2-22). The maximum concentration of aldrin in surface sediment (691~~J~~J µg/kg) is located at Station G355 (RM 7.3W). Concentrations greater than 1 µg/kg were observed from RM 3W through RM 10W. Mean concentrations by river mile in the western nearshore zone are ~~0.60.552~~J µg/kg at RM 3W-4W, ~~0.60.595~~J at RM 4W-5W, 1.0~~1~~J µg/kg at RM 5W-6W, 3.4~~1~~J µg/kg at RM 6W-7W, 40.~~4~~J µg/kg at RM 7W-8W, ~~4413.5~~J µg/kg at RM 8W-9W, and 1.0 µg/kg at RM 9W-10W (Table 5.2-7).

Dieldrin was reported at concentrations greater than 10 µg/kg in the western nearshore zone at RM 6.3W, RM 7.3W and RM 8.3W through 8.8W. Reported concentrations greater than 100 µg/kg were noted at RM 8.8W (Figure 5.2-25). The maximum reported concentration of dieldrin (356~~J~~J µg/kg) is located at Station G453 (RM 8.8W). Concentrations greater than 1 µg/kg are observed at RM 3.3W, from RM 5.5W through 9.8W, and at RM 11.3W. Mean concentrations by river mile are ~~0.30.294~~J µg/kg at RM 3W-4W, 0.4~~27~~J µg/kg at RM 5W-6W, 1.8~~3~~J µg/kg at RM 6W-7W, ~~2.92.85~~J µg/kg at RM 7W-8W, ~~2928.7~~J µg/kg at RM 8W-9W, and 2.50 µg/kg at RM 11W-11.8W (Table 5.2-7).

Neither aldrin nor dieldrin were detected in the navigation channel at concentrations greater than 10 µg/kg (Figures 5.2-22 and 5.2-25). Concentrations of aldrin greater than 1 µg/kg were observed from RM 2 to 3, RM 5 to 7.5, and at RM 9.3. Mean concentrations (Table 5.2-5) in these areas are: 0.738 µg/kg at RM 1.9-3, 1.21.15 µg/kg at RM 5-6, 0.8+0.806 µg/kg at RM 6-7, and 0.70.688 µg/kg at RM 9-10. Dieldrin was reported at concentrations greater than 1 µg/kg at RM 5.6 and RM 6.4. Mean concentrations in these areas are 0.711 at RM 5-6 and 0.50.494 µg/kg at RM 6-7.

Aldrin was reported at a concentration greater than 100 µg/kg in surface sediment in two results, 12 detected were between 10 and 100 µg/kg, 67 results were between 1 and 10 µg/kg, 187 (70 percent) were reported at concentrations less than 1 µg/kg (Table 5.2-9).

A single dieldrin result was reported at a concentrations greater than 100 µg/kg in surface sediment, six were between 10 and 100 µg/kg, 33 were reported at concentrations between 1 and 10 µg/kg, 212 samples (84 percent) were less than 1 µg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Aldrin was reported in 3 of 25 surface sediment samples within the Downstream reach (frequency of detection 12 percent). Concentrations reported range from 0.37 J to 0.4J µg/kg (Table 5.2-19, Table 5.2-21) with a mean of 0.40.39 µg/kg. Dieldrin was reported in one of 25 surface sediment samples a concentration of 0.070.069 J µg/kg.

5.2-9.35.2.8.3 Aldrin and Dieldrin in Subsurface Sediment

Upriver Reach (RM 15.3 to 26)

Aldrin and dieldrin were not detected in the three subsurface sediment samples collected between RM 15.4 and. Detection limits ranged up to was 0.2 µg/kg for aldrin and 0.036 µg/kg for dieldrin (Table 5.2-12).

Downtown Reach (RM 11.8 to 15.3)

Aldrin was reported in 8 of 94 subsurface sediment samples within the Downtown reach (frequency of detection nine percent). Concentrations reported range from 0.080.079 J to 1.7 µg/kg (Table 5.2-15a) with a mean concentration of 0.414 µg/kg. With the exception of the 1.7 µg/kg, result, all reported values were less than 1 µg/kg (Table 5.2-17).

Dieldrin was reported in 4 of 94 subsurface sediment samples (frequency of detection four percent), concentrations reported range from 0.2.9J to 16.J µg/kg (Table 5.2-15a, Table 5.2-17), with a mean concentration of 7.06 µg/kg.

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the

Downtown data set. None of the aldrin or dieldrin data was excluded from the Downtown reach.

Study Area Reach (RM 1.9 to 11.8)

Aldrin was reported in 135 of 1,172 subsurface sediment samples within the Study Area (frequency of detection 12 percent), concentrations reported range from 0.110 J $\mu\text{g/kg}$ to 1,340J $\mu\text{g/kg}$ (Table 5.2-1), with a mean of 523.3 $\mu\text{g/kg}$. The spatial distribution of aldrin in subsurface sediment within the Study Area is presented on Figure 5.2-23.

Dieldrin was reported in 77 of 1,208 subsurface sediment (frequency of detection six percent). Concentrations reported range from 0.040.0380 NJ to 100J $\mu\text{g/kg}$ (Table 5.2-1), with a mean of 43.60 $\mu\text{g/kg}$. The spatial distribution of dieldrin in subsurface sediment also is presented on Figure 5.2-26.

The maximum reported concentration (3.81 NJ $\mu\text{g/kg}$) of aldrin in subsurface sediment in the eastern nearshore zone was at Station C019-1 at RM 2.3E. Concentrations greater than 1 $\mu\text{g/kg}$ were observed from RM 1.9E to 5.66.7E and at RM 11.2E (Figure 5.2-23). Mean concentrations by river mile are 1.00.989 $\mu\text{g/kg}$ at RM 1.9E-3E, 0.70.667 $\mu\text{g/kg}$ at RM 3E-4E, 0.717 $\mu\text{g/kg}$ at RM 4E-5E, 0.920 $\mu\text{g/kg}$ at RM 5E-6E, 0.561 $\mu\text{g/kg}$ at RM 6E-7E, and 1.80 $\mu\text{g/kg}$ at RM 11E to 11.8E (Table 5.2-4).

Dieldrin was reported in subsurface sediment at a maximum concentration- of 100 $\mu\text{g/kg}$ in the eastern nearshore zone at RM 3.7E (Station C092; 30–152 cm bml) at the head of the International Terminals Slip (Figure 5.2-26; Table 5.2-4).

The maximum reported aldrin concentration in subsurface sediment (1,340 J $\mu\text{g/kg}$) in the western nearshore zone was observed at RM 7.4W at Station C356, 136–256 cm bml (Figure 5.2-23). Aldrin concentrations in sediment greater than 1 $\mu\text{g/kg}$ are observed from 4.5W to RM 8.8W, concentrations greater than 10 $\mu\text{g/kg}$ were observed from RM 6.1W through RM 8.8W, and concentrations greater than 100 $\mu\text{g/kg}$ were reported at RM 6.1W and RM 8.8W (Figure 5.2-23). Mean concentrations in these areas are 0.851 $\mu\text{g/kg}$ at RM 4W-5W, 1.90 $\mu\text{g/kg}$ at RM 5W-6W, 29.28.9 $\mu\text{g/kg}$ at RM 6W-7W, 73.72.5 $\mu\text{g/kg}$ at RM 7W-8W, and 6867.9 $\mu\text{g/kg}$ at RM 8W-9W (Table 5.2-8). Reported dieldrin concentrations greater than 10 $\mu\text{g/kg}$ in the western nearshore zone occur between RM 6W and 8.8W (Figure 5.2-26), mean concentrations in these areas are: 4.52 $\mu\text{g/kg}$ at RM 6W -7W; 4.03.95 $\mu\text{g/kg}$ at RM 7W-8W, and 17.3 $\mu\text{g/kg}$ at RM 8W-9W (Table 5.2-8).

Within the navigation channel, Aldrin concentrations greater than 10 $\mu\text{g/kg}$ were noted at RM 6.4, sediment concentrations greater than 1 $\mu\text{g/kg}$ were detected from RM 6 to 7 and at RM 10.3 (Figure 5.2-23). The maximum reported aldrin concentration (44J $\mu\text{g/kg}$) within the navigation channel was observed at core Station C299 (RM 6.4

near the west bank). Mean concentrations in these areas are ~~43~~12.9 µg/kg at RM 6-7, and ~~0.70~~0.667 µg/kg at RM 10-11 (Table 5.2-6).

Dieldrin was reported at a concentration greater than 10 µg/kg in only one sample located within the navigation channel at Station WR-CD-40 (13 µg/kg) near RM 11.3. Concentrations above 1 µg/kg were also reported in cores collected at RM 3.5, 6.1, and 11.2. Mean concentrations in these areas are ~~0.80~~0.750 µg/kg at RM 3-4, ~~3.00~~ µg/kg at RM 6-7, and ~~5.65~~5.55 µg/kg at RM 11-11. ~~9.8~~ (Table 5.2-6).

Downstream Reach (RM 0 to 1.9)

Aldrin was reported in 3 of 26 subsurface sediment samples within the Downstream reach (frequency of detection 12 percent). Reported concentrations range from 0.2 ~~J~~ to 2.8 ~~NJ~~ µg/kg (Table 5.2-19), with a mean of 1.2 µg/kg. Dieldrin was not reported within the Downstream reach.

5.2.9.45.2.8.4 Aldrin and Dieldrin Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentration by reach and also by subareas within the Study Area reach. There are insufficient data to compare surface and subsurface concentrations in the Upriver reach. ~~Mean concentrations in surface sediment are 0.334 and 0.209 µg/kg for~~ aldrin and dieldrin, respectively.

Commented [Integral38]: As above.

Within the Downtown reach, mean aldrin and dieldrin concentrations were greater in subsurface versus surface sediment. Mean surface and subsurface concentrations 0.26 ~~2~~ and 0.41 ~~4~~ µg/kg for aldrin, and ~~0.270~~0.266 and ~~7.06~~ µg/kg for dieldrin, respectively.

Within the Study Area, aldrin and dieldrin concentrations are also generally greater in subsurface than in surface sediments. Study Area-wide, mean surface and subsurface concentrations are ~~4.94~~4.89 and 23. ~~3~~ µg/kg for aldrin and ~~2.62~~2.56 and 3.6 ~~0~~ µg/kg for dieldrin. Exceptions to this general trend are noted in the western nearshore zone at RM 9W-10W where the mean aldrin concentration is greater in surface sediment, at RM 8W-9W where the mean dieldrin concentration is greater in surface sediment, and at RM 11-11.8W where both aldrin and dieldrin mean concentrations are greater in surface sediment (Figures 5.2-24 and 27).

In Swan Island Lagoon, the mean aldrin and dieldrin concentrations are greatest in surface sediment. Mean dieldrin in surface sediment are greater at RM 1.9E to 3E, RM 5E to 6E. Within the navigation channel, mean aldrin and dieldrin concentrations in surface sediment concentrations are greater than in subsurface sediment.

Insufficient data are available in the Downstream reach to allow meaningful comparisons between surface and subsurface sediment concentrations.

5.2.9.55.2.8.5 Arsenic in Sediment

The distribution of arsenic concentrations at each surface sediment sampling station throughout the Study Area is depicted on Map 5.2-25; concentrations with depth at subsurface stations are depicted on Maps 5.2-26a-o. If more than one sample was analyzed at the same surface sediment location, the greater of the two samples is presented on these maps, all subsurface samples are presented.

Figures 5.2-28 and 5.2-29 present scatter plots of the arsenic data set for surface and subsurface sediment in the Study Area, respectively. The scatter plots present the data in three panels segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-~~33~~35).

Summary statistics for arsenic in surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2, respectively. Summary statistics for surface and subsurface sediment within the eastern nearshore, navigation channel, and western nearshore zones are presented in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Tables 5.2-9 and 5.2-10 present arsenic data as orders of magnitude (e.g., <1, 1-10, 10-100, 100-1,000, etc.) for only detected values and for combined detected and nondetect values. Finally, a histogram presenting the average surface and subsurface sediment values by river mile and for the entire Study Area is in Figure 5.2-30.

Data sets for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables. Additionally, the Downtown reach surface sediment samples are presented in Map 5.2-45. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12; number of data points by order of magnitude are provided in Tables 5.2-13 (detects only) and 5.2-14 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downtown reach are shown in Tables 5.2-15 and 5.2-16; number of data points by order of magnitude are provided in Tables 5.2-17 (detects only) and 5.2-18 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20, number of data points by order of magnitude are provided in Tables 5.2-21 (detects only) and 5.2-22 (detects and nondetects).

5.2.9.65.2.8.6 Arsenic Data Set

Arsenic results includes 1,551 surface and 1,553 subsurface samples from within the Study Area, 77 surface and 3 subsurface samples from the Upriver reach, 233 surface and 178 subsurface samples from the downtown reach, and 25 surface and 26 subsurface samples from the downstream reach.

5.2.9.75.2.8.7 Arsenic in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

Arsenic was reported in 73 of 77 surface sediment samples within the Upriver reach (frequency of detection 95 percent). Concentrations ranging from 1.9 J mg/kg to 5.35.29 mg/kg (Table 5.2-11), with a mean of 2.94 mg/kg.

Downtown Reach (RM 11.8 to 15.3)

Arsenic was reported in 201 of 233 surface sediment within the Downtown reach (frequency of detection 86 percent). Concentrations reported range from 4.41.07 to 1264 mg/kg (Table 5.2-15a), with a mean concentration of 6.2 mg/kg. The spatial distribution of arsenic within the Downtown reach is presented on Map 5.2-45. The majority of results are less than 5 mg/kg, localized areas with concentrations greater than 25 mg/kg were observed at RM 13 under the Hawthorn Bridge and on the western shore between the Marquam and Ross Island bridges.

Commented [Integral39]: Concentrations >24 mg/kg also present on western shore.

One result was reported at a concentration greater than 100 mg/kg, 17 results were between 10 and 100 mg/kg, 183 results (91 percent of the detected data set) were less than 10 mg/kg, and no detected results were reported at concentrations less than 1 mg/kg (Table 5.2-17).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. Arsenic was reported in 74 surface sediment samples within the Zidell action area, reported concentrations range from 4.31.29 to 78 J mg/kg (Table 5.2-15c). The mean arsenic concentration for this area is 11.2 mg/kg. When the data for the Zidell facility is removed from the downtown data set (Table 5.2-15b), the range of arsenic concentrations in surface sediment is from 4.41.07 to 126 mg/kg with a mean concentration of 4.71 mg/kg.

Study Area Reach (RM 1.9 to 11.8)

Arsenic was reported in 1,426 of 1,551 surface sediment samples within the Study Area (frequency of detection 92 percent). Concentrations reported range from 0.700 to 132 mg/kg (Table 5.2-1), with a mean of 4.54.86 mg/kg. The spatial distribution of arsenic concentrations within the Study Area is presented on Figure 5.2-28.

Within the eastern nearshore zone, sediment concentrations approaching or greater than 100 mg/kg were observed identified in the eastern nearshore zone at RM 2.3E, RM 5.6E, and RM 7.2E (Figure 5.2-28). Areas where concentrations are greater than 10 mg/kg occur at near RM 5.5E, RM 7E, and in Swan Island Lagoon (Figure 5.2-28, Map 5.2-25). The highest surface concentration detected in the eastern nearshore zone (132 mg/kg) was found at Station RB08 at RM 2.3. Mean concentrations (Table 5.2-3) for these areas are: 5.85.76 mg/kg at RM 1.9E-3E, 7.05 mg/kg at RM 5E-6E, 7.27.16 mg/kg at RM 7E-8E, and 5.95.87 mg/kg in Swan Island Lagoon.

Areas in the western nearshore zone where arsenic concentrations exceed 10 mg/kg occur from RM 3.5W through 7W, RM 8.3W to 9.2W, and at RM 10.2W. Three localized areas where reported concentrations are greater than 50 mg/kg are located at RM 6.8W, RM 8.6W (80 mg/kg at Station A2GS10), and RM 10.2W (Figure 5.2-28). Mean concentrations in these areas are ~~4.94~~4.86 mg/kg at RM 3W-4W, ~~4.10~~ mg/kg at RM 4W-5W, ~~4.12~~ mg/kg for RM 5W-6W, ~~65.99~~ mg/kg at RM 6W-7W, ~~9.29~~17 mg/kg at RM 8W-9W, ~~5.85~~79 mg/kg at RM 9W-10W, and ~~409.96~~ mg/kg at RM 10W-11W (Table 5.2-7). There were no reported arsenic concentrations in surface sediment exceeding 10 mg/kg in the navigation channel

Within the Study Area, arsenic was reported in surface sediment at a concentration greater than 100 mg/kg in two results, 57 were between 10 and 100 mg/kg, 1,364 (96 percent of the detected results) were reported at concentrations between 1 and 10 mg/kg, and three were reported at concentrations less than 1 mg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Arsenic was reported in all 25 surface sediment samples within the Downstream reach, concentrations reported range from 0.6 J to 6.4 mg/kg (Table 5.2-19). One result was reported at a concentration less than 1 mg/kg, the remaining 24 results were between 1 and 10 mg/kg (Table 5.2-21). The mean arsenic concentration in this reach is 3.7 mg/kg.

5.2-9.85.2.8.8 Arsenic in Subsurface Sediment

Upriver Reach (RM 15.3 to 26)

Arsenic was analyzed and reported in only three subsurface samples between RM 15.4 and 16. Concentrations reported range from ~~2.42~~37 to ~~2.52~~45 mg/kg.

Downtown Reach (RM 11.8 to 15.3)

Arsenic was reported in 168 of 178 subsurface sediment samples within the Downtown reach (frequency of detection 94 percent). Concentrations reported from 0.57 mg/kg to 7.5 mg/kg (Table 5.2-16a), with a mean of ~~3.02~~96 mg/kg. The majority of the results (165 samples) were reported at concentrations between 1 and 10 mg/kg, the remaining three results were reported at concentrations less than 1 mg/kg (Table 5.2-17).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-16b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-16c presents the data statistics for the Zidell data removed from the Downtown data set. Arsenic was analyzed in 30 subsurface sediment samples within the Zidell action area, reported concentrations range from 2 to 7.5 mg/kg, with a mean concentration in this area of 3.5 mg/kg. When the data for the Zidell facility is removed from the downtown data set (Table 5.2-16c), the range of reported concentrations in subsurface sediment is 0.57 to ~~7.27~~19 mg/kg, with a mean of ~~2.92~~89 mg/kg.

Study Area Reach (RM 1.9 to 11.8)

Arsenic was reported in 1,489 of 1,553 subsurface samples within the Study Area (frequency of detection 96 percent). Concentrations reported range from 0.500 J to ~~51.4~~

mg/kg (Table 5.2-2) with a mean of ~~4.4~~4.08 mg/kg. The spatial distribution of reported arsenic concentrations in subsurface sediment is presented on Figure 5.2-29 and Maps 5.2-26a-o).

Within the eastern nearshore zone, arsenic concentrations in subsurface sediment exhibits a different pattern than observed in surface sediment (Figure 5.2-30). Concentrations greater than 10 mg/kg occur at RM 3.6E, RM 4.6E, RM 5.6E, RM 8.5E, RM 11.3E, and in Swan Island Lagoon (Figure 5.2-29 and Map 5.2-26a-o). Single points are noted at RM 6.7E and RM 7.4E. The highest reported subsurface concentration of 51 mg/kg was observed in the interval of 150–236 cm bml at Station C708, near the mouth of Swan Island Lagoon. Mean concentrations in these areas are 3.61 mg/kg at RM 3E-4E, ~~3.5~~3.47 mg/kg at RM 4E-5E, ~~5.4~~5.37 mg/kg at RM 5E-6E, 4.11 mg/kg at RM 6E-7E, 4.11 mg/kg at RM 7E-8E, ~~41.8~~11.5 mg/kg at RM 8E-9E, 4.81 mg/kg in Swan Island Lagoon, and 4.73 mg/kg at RM 11E-11.8E (Table 5.2-3).

Arsenic concentrations greater than 10 mg/kg were reported in the western nearshore zone from RM 3.6W through 9.2W, most prominently between RM 8.6W and 9.2W (Figure 5.2-29). The maximum reported value in the western nearshore zone was 43.3 mg/kg at Station HA-38 at RM 9.0. Mean concentrations in this area are ~~6.4~~6.07 mg/kg at RM 3W-4W, 4.04 mg/kg at RM 4W-5W, 4.25 mg/kg at RM 5W-6W, 3.61 mg/kg at RM 6W-7W, 4.34 mg/kg at RM 7W-8W, ~~5.7~~5.67 mg/kg at RM 8W-9W, and 8.11 mg/kg at RM 9W to 10W (Table 5.2-8).

Only three results from within the navigation channel were reported at a concentration greater than 10 mg/kg, at RM 7.9, 10.3 and 11.5. Within these areas, mean arsenic concentrations are ~~4.24~~1.8 mg/kg at RM 7-8; 4.02 mg/kg at RM 10-11, and 3.03 mg/kg at RM 11-11.8 (Table 5.2-6).

Of the reported arsenic concentrations in subsurface sediment, 45 results were greater than 10 mg/kg, 1,433 results (96 percent of the reported results) were between 1 and 10 mg/kg, and 11 were reported at concentrations less than 1 mg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Arsenic was reported in all 26 subsurface sediment samples collected within the Downstream reach, with reported concentrations ranging from 0.6 J mg/kg to 13 mg/kg (Table 5.2-20). Table 5.2-21 shows that there is one sample detected at a concentration greater than 10 mg/kg. The majority of the samples (24 samples; 92 percent) were detected at concentrations between 1 and 10 mg/kg. Only one sample was detected at a concentration less than 1 mg/kg. The mean arsenic concentration in this reach is ~~4.4~~4.06 mg/kg.

5.2.9.95.2.8.9 Arsenic Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentrations by reach, and also by subareas with the Study Area reach.

There are insufficient data to allow for a meaningful comparison of surface and subsurface concentrations in the Upriver reach. ~~The~~ The mean arsenic surface sediment concentration in this reach is 2.94 mg/kg (Table 5.2-11).

Commented [Integral40]: As above.

Surface sediment concentrations in the downtown reach were greater than the subsurface concentrations, ~~indicating-suggesting~~ that there may be ongoing sources in this reach. The mean surface concentration is 6.2 mg/kg, while the mean subsurface sediment concentration is 3.02.96 mg/kg (Tables 5.2-15a and 5.2-16a).

Arsenic concentrations are also generally greater in the surface sediments than in subsurface sediments within the Study Area as a whole. The mean surface sediment concentration is 4.54.86 mg/kg and the mean subsurface sediment concentration is 4.14.08 mg/kg (Tables 5.2-1 and 5.2-2). Figure 5.2-30 shows that mean concentrations are greater in the nearshore areas than in the navigation channel and the western nearshore zone is slightly greater than the eastern nearshore zone. It also shows that concentrations are generally greater in the surface sediment than in subsurface sediment.

In the eastern nearshore zone, surface sediment is greater than subsurface sediment in all river mile zones except RM 8 to 9 and RM 11 to 11.8. In the western nearshore zone, subsurface sediment concentrations are greater than surface sediment in all river miles except RM 4W to 5W, RM 6W to 7W, RM 8W to 9W, and possibly RM 10 to 11. The subsurface sediment concentrations in the navigation channel are generally the same as the surface sediment concentrations.

Areas where subsurface sediment concentrations are elevated do not align with the locations where surface sediment concentrations are elevated. The most prominent areas are RM 8E to 9E in the eastern nearshore zone, and RM 8W to 9W and RM 10 to 11W in the western nearshore zones. Additional areas ~~with-where~~ elevated concentrations ~~do not align~~ are RM 1.9E to 3E, RM 5E to 6E, RM 7E to 8E, and Swan Island lagoon in the eastern nearshore zone, and RM 3W to 4W, RM 6 to 7W, and RM 8W to 10W in the western nearshore zone (Figure 5.2-30).

The surface sediment concentrations in the downstream reach were greater than subsurface concentrations. The mean surface concentration is 4.13.7 mg/kg, while the mean subsurface concentration is 3.84.06 mg/kg (Tables 5.2-19 and 5.2-20).

~~5.2.105.2.9~~ Chromium in Sediment

The distribution of chromium concentrations in surface sediment throughout the Study Area is depicted on Map 5.2-27, subsurface results are depicted on Maps 5.2-28a-o. If more than one sample was analyzed from the same surface sediment location, the greater of the two results is presented; all subsurface samples are presented.

Scatter plots of the chromium data from within the Study Area are presented on Figures 5.2-31 and 5.2-32, respectively, for surface and subsurface sediment segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-33).

Summary statistics for surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2. Summary statistics for surface and subsurface sediment within the eastern nearshore, navigation channel, and western nearshore zones are presented in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Chromium results by orders of magnitude (<1, 1-10, 10-100, 100-1,000, etc.) are presented for detected values in Table 5.2-9, and for combined detected and nondetect results in Table 5.2-10. A histogram of average surface and subsurface sediment values by river mile and for the Study Area is presented on Figure 5.2-33.

Results for the Upriver, Downtown, and Downstream reaches are presented in statistical tables and order of magnitude tables. Additionally, surface sediment results for the Downtown reach are presented in Map 5.2-46. Summary statistics for surface and subsurface sediment results within the Upriver reach are shown in Tables 5.2-11 and 5.2-12, respectively. Results by order of magnitude are provided in Tables 5.2-13 (detects only) and 5.2-14 (detects and nondetects). Summary statistics for surface and subsurface sediment results within the Downtown reach are shown in Tables 5.2-15 and 5.2-16, respectively, the number of results by order of magnitude are provided in Tables 5.2-17 (detects only) and 5.2-18 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20, respectively, the number of results by order of magnitude are provided in Tables 5.2-21 (detects only) and 5.2-22 (detects and nondetects).

5.2-10-15.2.9.1 Chromium Data Set

The Study Area chromium data set consists of 1,536 surface and 1,530 subsurface samples. The Upriver data set consists of 66 surface and 3 subsurface samples, the downtown data set consists of 265 samples and 178 subsurface samples, and the downstream data consists of 25 surface and 26 subsurface samples.

5.2-10-25.2.9.2 Chromium in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

Chromium was reported in all 66 surface sediment samples within the Upriver reach, reported concentrations ranged from ~~12.1~~ 11.9 J to ~~41~~ 40.5 mg/kg (Table 5.2-11), all results were between 10 and 100 mg/kg with a mean of 23.1 mg/kg (Table 5.2-13).

Downtown Reach (RM 11.8 to 15.3)

Chromium was reported in all 265 surface sediment samples within the Downtown reach. Concentrations reported ranged from 1.2 4 J to 758 J mg/kg (Table 5.2-15a), with a mean concentration of ~~35~~ 34.6 mg/kg. The majority of the results are less than 50 mg/kg, with concentrations greater than 50 mg/kg present at RM 13 on the western

shore [downstream of](#) the Hawthorn Bridge and on the western shore between the Marquam and Ross Island bridges (Map 5.2-46).

Within the Downtown reach, 14 results (5 percent of data set) were reported at concentrations greater than 100 mg/kg, 218 results (82 percent) were between 10 and 100 mg/kg, and 33 results (12 percent) were reported at concentrations less than 10 mg/kg (Tables 5.2-17 and 5.2-18).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. Chromium was reported in 110 surface sediment samples within the Zidell action area with concentrations ranging from 1.24 [J](#) mg/kg to 758 [J](#) mg/kg (Table 5.2-15c), with a mean of 56.0 mg/kg. When the data for the Zidell facility is removed from the downtown data set (Table 5.2-15b), the range of chromium concentrations in surface sediment is from 4.5 [J](#) mg/kg to 189 mg/kg with a mean concentration of 19.4 mg/kg.

Study Area Reach (RM 1.9 to 11.8)

Chromium was reported in 1,530 of 1,536 surface sediment samples within the Study Area (detection frequency of 99.6 percent). Reported concentrations ranged from [4.14.07 J](#) to 819 [J](#) mg/kg (Table 5.2-1), with a mean of 35.4 mg/kg.

Concentrations greater than 100 mg/kg are present in the eastern nearshore zone at RM 2.1 [E](#)-2.4 [E](#), RM 3.7 [E](#)-4.4 [E](#), RM 5.6 [E](#)-5.9 [E](#), and in Swan Island Lagoon (Figure 5.2-31 and Map 5.2-27), single results greater than 100 mg/kg are present at RM 7.2 [E](#) and RM 1 [E](#)1. The maximum reported concentration in the eastern nearshore zone (819 [J](#) mg/kg) was found at Station RB06 at RM 2.2. Mean concentrations (Table 5.2-3) in these areas in the eastern nearshore zone are ~~100~~99.9 mg/kg at RM 1.9 [E](#)-3 [E](#), ~~34~~30.7 mg/kg at RM 3 [E](#)-4 [E](#); 29.3 mg/kg at RM 4 [E](#)-5 [E](#), 45.1 mg/kg at RM 5 [E](#)-6 [E](#), ~~35~~34.9 mg/kg at RM 7 [E](#)-8 [E](#), 35.4 mg/kg in Swan Island Lagoon, and ~~38~~37.7 mg/kg at RM 11 [E](#)-11.8 [E](#).

Reported concentrations in the western nearshore zone greater than 100 mg/kg are located at RM 6 [W](#)-6.1 [W](#), RM 6.8 [W](#)-6.9 [W](#), and RM 8.8 [W](#)-9.2 [W](#) (Figure 5.2-31). The maximum reported concentration of chromium in surface sediment of 774 mg/kg was found at Station 19A01 (RM 8.4 [W](#)). Mean concentrations in these areas are ~~39~~38.8 mg/kg at RM 6 [W](#)-7 [W](#), ~~35~~34.8 mg/kg at RM 7 [W](#)-8 [W](#), ~~47~~46.9 mg/kg at RM 8 [W](#)-9 [W](#), and 39.1 mg/kg at RM 9 [W](#)-10 [W](#) (Table 5.2-7). All chromium results from the navigation channel were less than 100 mg/kg.

Thirty-nine results were reported at concentrations greater than 100 mg/kg, 1,466 results (96 percent) were reported at concentrations between 10 and 100 mg/kg, and the remaining 25 results were reported at concentrations less than 10 mg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Chromium was reported in all 25 surface sediment samples within the Downstream reach. Reported concentrations range from 10.4 J to 42.2 mg/kg (Tables 5.2-19 and 5.2-21), with a mean concentration of 25.7 mg/kg.

5.2.10.35.2.9.3 Chromium in Subsurface Sediment

Upriver Reach (RM 15.3 to 26)

Chromium concentrations were analyzed in only three subsurface samples between RM 15.4 and 16. The samples were all detected at levels ranging from 20.7 mg/kg to 23.4 mg/kg; the average concentration for this reach is 21.2 mg/kg.

Downtown Reach (RM 11.8 to 15.3)

Chromium was reported in 174 of 178 subsurface sediment samples within the Downtown reach. Concentrations reported ranged from 4.64.56 to 143 mg/kg (Table 5.2-16a), with a mean of 22.2 mg/kg. Table 5.2-17 shows that only one result was reported at a concentration greater than 100 mg/kg, 161 results (93 percent of reported results) were reported at concentrations between 1 and 10 mg/kg, 12 results were reported at concentrations less than 1 mg/kg.

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Data statistics for the Downtown reach excluding the Zidell data are presented in Table 5.2-16b presents, and Table 5.2-16c presents statistics with the Zidell data removed from the Downtown data set. Chromium was reported in 30 subsurface sediment samples within the Zidell action area, concentrations reported ranged from 14 to 143 mg/kg, with a mean of 36 mg/kg. When data from the Zidell facility are excluded from the downtown data set, reported chromium concentrations in subsurface sediment ranged from 4.64.56 to 72.71.7 mg/kg, with a mean of 19.4 mg/kg.

Study Area Reach (RM 1.9 to 11.8)

Chromium was reported in 1,524 of 1,530 subsurface samples. Reported concentrations ranged from 6.41 J to 484464 mg/kg (Table 5.2-2), with a mean of 2928.8 mg/kg. The distribution of reported chromium concentrations in subsurface sediment within the Study Area is shown on Figure 5.2-32.

Concentrations greater than 100 mg/kg were observed within the eastern nearshore zone at RM 2.2E-2.4E, RM 5E-6E and in Swan Island Lagoon (Figure 5.2-32 and Map 5.2-28a-o). The highest reported subsurface concentration in the eastern nearshore zone (249 mg/kg) was found at Station C207-1 near RM 5.6E. Mean concentrations in these areas are 30.5 mg/kg at RM 1.9E-3E, 56.0 mg/kg at RM 5E-6E, and 31.0 mg/kg in Swan Island Lagoon (Table 5.2-3).

Reported chromium concentrations greater than 100 mg/kg are present in the western nearshore zone at RM 6.1W, RM 7.4W, and RM 8.8W-9.2W (Figure 5.2-32). The maximum subsurface concentration (484464 mg/kg) was found at Station HA-42 (46–61 cm bml) at RM 8.99.1W. Mean concentrations in these areas are 30.3 mg/kg at

RM 6W-7W, 32.3 mg/kg at RM 7W-8W; 35.2 mg/kg for RM 8W-9W; and 60.5 mg/kg for RM 9W-10W. (Table 5.2-8)

Within the navigation channel, chromium greater than 100 mg/kg was reported at RM 6.4 and 11.3. Mean concentrations for these areas are 22.9 mg/kg at RM 6-7 and 21.5 mg/kg at RM 11-11.8 (Table 5.2-6).

Fourteen results were reported at concentrations greater than 100 mg/kg, 1,452 results were between 10 and 100 mg/kg, and 58 results are comprised of concentrations less than 10 mg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Chromium was reported in all 26 subsurface sediment samples collected within the Downstream reach. Concentrations reported ranged from 6.6 to 33.8 mg/kg (Tables 5.2-20 and 5.2-21), with a mean of 23.2 mg/kg.

5.2.10.45.2.9.4 Chromium Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentrations by reach and also by subareas with the Study Area reach. There is insufficient data to compare surface and subsurface concentrations in the Upriver reach

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Within the downtown reach, chromium concentrations are greater in surface sediment than in subsurface sediment, the mean surface concentration is 34.6 mg/kg, while the mean subsurface sediment concentration is 22.2 mg/kg (Tables 5.2-15a and 5.2-16a).

Within the Study Area, chromium concentrations are also generally greater in the surface sediments than in subsurface sediments as a whole. Mean concentrations are 35.4 mg/kg in surface and 29.8 mg/kg subsurface sediment (Tables 5.2-1 and 5.2-2, Figure 5.2-33). Mean concentrations are greater in the nearshore areas than in the navigation channel.

Within the eastern nearshore zone, concentrations surface sediment are greater than in subsurface sediment in all river mile except RM 5E-7E and RM 8E-9E. Within the western nearshore zone, chromium concentrations in subsurface sediment concentrations are greater than in surface sediment in all river miles except RM 9W-10W and RM 11W-11.8W. Within the navigation channel, surface and subsurface sediment concentrations are generally comparable. The highest concentrations of chromium in subsurface sediment align with areas where surface sediment concentrations are greatest.

Within the downstream reach, concentrations in surface sediment are generally greater than in subsurface sediment. The mean surface concentration is 25.7 mg/kg, while the mean subsurface concentration is 23.2 mg/kg (Tables 5.2-19 and 5.2-20).

5.2.11.5.2.10 Copper in Sediment

The distribution of copper concentrations throughout the Study Area is depicted on Map 5.2-29, reported concentrations with depth at subsurface stations are depicted on Maps 5.2-30a-o. If more than one sample was analyzed at the same surface sediment location, the greater of the two samples is presented on these maps, all subsurface samples are presented. Scatter plots of the copper data set for surface and subsurface sediment in the Study Area are presented on Figures 5.2-34 and 5.2-35, respectively, segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-~~33~~35).

Summary statistics for copper in surface and subsurface sediment within the Study Area are shown in Tables 5.2-1 and 5.2-2. Summary statistics for surface and subsurface sediment within the eastern nearshore, navigation channel, and western nearshore zones are presented in Tables 5.2-3 and 5.2-4, Tables 5.2-5 and 5.2-6, and Tables 5.2-7 and 5.2-8, respectively. Reported copper concentrations as orders of magnitude are presented in Table 5.2-9 (detected results only) and Table 5.2-10 (combined detect and nondetect results). Finally, a histogram presenting the average surface and subsurface sediment values by river mile and for the entire Study Area is in Figure 5.2-36.

Data for the Upriver, Downtown, and Downstream reaches are only presented in statistical tables and order of magnitude tables. Additionally, surface sediment data for the Downtown reach are presented in Map 5.2-47. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12, number of results by order of magnitude are provided in Tables 5.2-13 (detect only) and 5.2-14 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downtown reach are shown in Tables 5.2-15 and 5.2-16, number of data points by order of magnitude are provided in Tables 5.2-17 (detect only) and 5.2-18 (detect and nondetect). Summary statistics for surface and subsurface sediment within the Downstream reach are shown in Tables 5.2-19 and 5.2-20; number of data points by order of magnitude are provided in Tables 5.2-21 (detect only) and 5.2-22 (detect and nondetect).

5.2.11.15.2.10.1 Copper Data Set

Copper data for the Study Area data consists of 1,552 surface and 1,541 subsurface samples. The Upriver data set includes 72 surface and 3 subsurface samples, the downtown data set consists of 269 surface and 178 subsurface samples, and the downstream data set consists of 25 surface samples and 26 subsurface samples.

5.2.11.25.2.10.2 Copper in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

Copper was reported in all 72 surface sediment samples within the Upriver reach. Concentrations reported with detected concentrations ranged from 10.5 J m to 50.9 mg/kg, with a mean of ~~25~~24.6 mg/kg (Table 5.2-11). All detected values were between 10 and 100 mg/kg (Table 5.2-13).

Downtown Reach (RM 11.8 to 15.3)

Copper was reported in 264 of 269 surface sediment samples within the Downtown reach. Concentrations reported ranged from 5.51 to 2,150 J mg/kg with a mean of ~~999~~8.6 mg/kg (Table 5.2-15a). The distribution of copper concentrations in surface sediment within the Downtown reach is presented on Map 5.2-47. Reported concentrations are generally less than 300 mg/kg, although areas with concentrations greater than 600 mg/kg are noted at RM 13 on the western shore under the Hawthorn Bridge and on the western shore between the Marquam and Ross Island bridges.

Within the Downtown reach, seven results were reported at concentrations greater than 1,000 mg/kg, 29 were reported at concentrations between 100 and 1,000 mg/kg, 222 results (84 percent) were reported at concentrations between 10 and 100 mg/kg, and ~~26~~ results were reported at concentrations less than 10 mg/kg (Tables 5.2-17 and 5.2-18).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Table 5.2-15b presents the data statistics for the Downtown reach excluding the Zidell data and Table 5.2-15c presents the data statistics for the Zidell data removed from the Downtown data set. Copper was reported in 110 surface sediment samples within the Zidell action area, reported concentrations ranged from 5.51 to 2,150 J mg/kg (Table 5.2-15c), with a mean of 195 mg/kg. When the data for the Zidell facility is excluded from the downtown data set, reported copper concentrations in surface sediment range from ~~8.48~~39 to 366 mg/kg, with a mean of ~~333~~2.6 mg/kg (Table 5.2-15b).

Study Area Reach (RM 1.9 to 11.8)

Copper was reported in 1,548 of 1,552 surface sediment samples. Concentrations reported ranged from ~~6.26~~19 J to 2,830 mg/kg, with a mean of ~~64~~60.8 mg/kg (Table 5.2-1). The distribution of concentrations in surface sediment is presented on Figure 5.2-34.

Copper in surface sediment at concentrations greater than 100 mg/kg in surface sediment in the eastern nearshore zone are present at RM 2.1E-2.4E, RM 3.7E-4E, RM 5.5E-6.1E, Swan Island Lagoon, and RM 11.1E-11.3E (Figure 5.2-34 and Map 5.2-29). Single results greater than 100 mg/kg are present at RM 6.6E, RM 7.2E, and RM 9.9E. Mean concentrations (Table 5.2-3) in these areas are 42.0 mg/kg at RM 1.9E-3E, 38.0 mg/kg at RM 3E-4E, 135 mg/kg at RM 5E-6E, ~~53.5~~53.6 mg/kg at RM 6E-7E, 53.0 mg/kg at RM 7E-8E, 122 mg/kg in Swan Island Lagoon; 31.6 mg/kg at RM 9E-10E, and 161 mg/kg at RM 11E-11.8E. The highest reported concentration of 2,830 mg/kg copper was reported at RM 11.2E (Station UG01).

Areas where copper concentrations are reported greater than 100 mg/kg in the western nearshore zone are present from RM 4.3W through 10.4W, and in particular at RM 4.3W-4.7W, RM 5.6W-6.1W, RM 6.8W-7.4W, RM 8.3W-9.2W, and RM 10.2W-10.4W (Figure 5.2-34). The maximum reported concentration in the western nearshore

zone of 1,370 mg/kg was found at Station HA-43 (RM 9.2W). Mean concentrations in these areas are 39.8 mg/kg at RM 4W-5W, 50.7 mg/kg at RM 5W-6W, 46.9 mg/kg at RM 6W-7W, 41.4 mg/kg at RM 7W-8W, 102 mg/kg at RM 8W-9, 110 mg/kg at RM 9W-10W, and 164 mg/kg at RM 10W-11W (Table 5.2-7).

Within the navigation channel, the highest reported copper concentrations are located at RM 5.5, RM 7.9, and RM 10.3-10.4. Reported concentrations at RM 5.5 and 7.9 appears to be associated with results observed in the eastern nearshore area, while the results RM 10.3-10.4 appear to be associated with observed concentrations in the western nearshore area (Map 5.2-29). The mean concentrations for these areas are 30.1 mg/kg at RM 5-6, 49.3 mg/kg at RM 7-8, 62.0 mg/kg in Swan Island Lagoon, and 39.7 mg/kg at RM 10-11 (Table 5.2-5).

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Within the Study Area, copper was reported at concentrations greater than 1,000 mg/kg in four results, 144 results were greater than 100 mg/kg, 1,392 results (90 percent of the detected results) were reported at concentrations between 10 and 100 mg/kg, and eight results were reported at concentrations less than 10 mg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Copper was reported in all 25 surface sediment samples within the Downstream reach (detection frequency of 100 percent), with concentrations ranging from 8 mg/kg to 4645.7 mg/kg (Table 5.2-19). Table 5.2-21 shows that 23 samples are measured at concentrations between 10 and 100 mg/kg and two samples are measured at concentration between 1 and 10 mg/kg. There were no samples were detected at concentrations less than 1 mg/kg. The mean copper concentration in this reach is 2625.5 mg/kg.

5.2.11.35.2.10.3 Copper in Subsurface Sediment

Upriver Reach (RM 15.3 to 26)

Only three subsurface sediment samples were analyzed for copper in the Upriver reach, all between RM 15.4 and 16. Reported concentrations range from 26 to 33 mg/kg, with a mean of 2928.6 mg/kg.

Downtown Reach (RM 11.8 to 15.3)

Copper was reported in all 178 subsurface sediment samples within the Downtown reach. Concentrations reported range from 9-59.48 to 1,050 mg/kg with a mean of 46.3 mg/kg (Table 5.2-16a). One result was reported at a concentration greater than 1,000 mg/kg, eight were reported at concentrations between 100 and 1,000 mg/kg, 167 results were reported at concentrations between 10 and 100 mg/kg, and two results were reported at concentrations less than 10 mg/kg (Table 5.2-17).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Summary statistics for the Downtown reach excluding the Zidell data are presented in Table 5.2-16b and Table 5.2-16c presents statistics for the Zidell data. Copper was reported in 30 subsurface sediment samples within the Zidell action area.

Concentrations reported range from 14 to 1,050 mg/kg, with a mean of 4282.1 mg/kg. Excluding the data from the Zidell site, reported concentrations range from 9.59.48 to 457 mg/kg, with a mean of 39.0 mg/kg (Table 5.2-16c).

Study Area Reach (RM 1.9 to 11.8)

Within the Study Area, copper was reported in 4,548 of 1,552 all 1,541 subsurface samples. Concentrations reported range from 9.42 J mg/kg to 3,290 mg/kg, with a mean of 55.2 mg/kg (Table 5.2-2). The distribution of concentrations in subsurface sediments is presented on Figure 5.2-35 and Maps 5.2-30a-o.

The subsurface sediment has elevated concentrations in generally the same areas identified in the surface sediment within the eastern nearshore zone (Figure 5.2-35). The maximum subsurface copper concentration (3,290 mg/kg) was found at Station C384 (30–128 cm bml), at the mouth of Swan Island Lagoon. Concentrations greater than 100 mg/kg are noted at RM 3.6E, RM 4.4E-4.6E, RM 5.6E, RM 6.1E-6.7E, RM 7.4E, in Swan Island Lagoon, RM 8.4E-8.8E, and RM 11.3E (Figure 5.2-35 and Map 5.2-30a-o). Mean copper concentrations in these areas in the eastern nearshore zone are 35.6 mg/kg at RM 3E-4E, 30.2 mg/kg at RM 4E-5E, 56.9 mg/kg at RM 5E-6E, 70.0 mg/kg at RM 6E-7E, 48.3 mg/kg at RM 7E-8E, 128 mg/kg at RM 8E-9E, and 145 mg/kg in Swan Island Lagoon (Table 5.2-34).

Within the western nearshore zone, copper concentrations exceeding 100 mg/kg are present from RM 4.1W through 9.2W, at RM 4.8 4.9 and RM 8.3 9.2 (Figure 5.2-35 and Map 5.2-30a-o). The maximum reported subsurface concentration of 1,990 mg/kg in the western nearshore zone was found at Station HA-42 (46–61 cm bml) at RM 8.99.1W. Mean concentrations in these areas are 48.0 mg/kg at RM 4W-5W, 33.9 mg/kg at RM 5W-6W, 39.4 mg/kg at RM 6W-7W, 42.6 mg/kg at RM 7W-8W, 59.8 mg/kg at RM W8-to-9W, and 229 mg/kg at RM 9W-10W (Table 5.2-8).

There are two areas as with results greater than 100 mg/kg in the navigation channel, located at RM 7.6-8 and RM 10.2-10.3. The results at RM 7.6-8 appear may be associated with concentrations observed in the eastern nearshore zone, and the results at RM 10.2-10.3 appear may be co-located with elevated concentrations the western nearshore zone (Maps 5.2-30a-o). The mean concentrations for these areas are 68.7 mg/kg at RM 7-8, and 51.4 mg/kg at RM 10-11 (Table 5.2-6).

Table 5.2-9 shows that there are a total of six results in subsurface sediment were ported at concentrations greater than 1,000 mg/kg, 78 results were between 100 and 1,000 mg/kg, 1,456 results were reported at concentrations between 10 and 100 mg/kg, and one result was than 10 mg/kg.

Downstream Reach (RM 0 to 1.9)

Copper was reported in all 26 subsurface sediment samples within the Downstream reach. Concentrations reported range from 8.9 to 4443.6 mg/kg, with a mean of 2625.7 mg/kg (Table 5.2-20). Table 5.2-21 shows that the majority of samples (a total of 24 of

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the 26 results) were reported at a concentration greater than 10 mg/kg, two samples were reported at a concentration less than 10 mg/kg.

5.2.11.45.2.10.4 Copper Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentrations by reach and also by subareas with the Study Area reach. There is insufficient data to compare surface and subsurface concentrations in the Upriver reach.

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The mean surface sediment concentrations of ~~9998.6~~ 60.8 mg/kg in the downtown reach is greater than the subsurface mean of 46.3 mg/kg (Tables 5.2-15a). However, when the Zidell data is excluded, the mean surface and subsurface sediment concentrations are similar (~~3332.6~~ 25.5 mg/kg and 39.0 mg/kg, respectively, Table 5.2-15b).

Copper concentrations in the subsurface sediments are generally comparable the concentration in the surface sediments within the Study Area as a whole (Figure 5.2-36). The mean surface sediment concentration is ~~6460.8~~ 60.8 mg/kg and the mean subsurface sediment concentration is ~~5555.2~~ 25.5 mg/kg (Tables 5.2-1 and 5.2-2). ~~Mean concentrations are greater in the nearshore areas than in the navigation channel, and the mean concentration in the eastern nearshore zone is greater concentrations than in the western nearshore zone.~~

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In the eastern nearshore zone, mean concentrations in surface sediment are greater than in subsurface sediment in all river mile zones except RM 6-7, RM 8-9, and in Swan Island Lagoon. In the western nearshore zone, mean concentrations in subsurface sediment are greater than in surface sediment in all river miles except RM 5-7 and RM 8-9. Within the navigation channel, mean subsurface and surface sediment concentrations are comparable, with the mean subsurface sediment concentrations slightly greater in all river miles except RM 1.9-3 and RM 4-7.

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Areas with the highest copper concentrations in subsurface sediment generally align with the locations where surface sediment concentrations are greatest, although there are more areas with only elevated surface or elevated subsurface sediment concentrations (Figure 5.2-36). Mean surface and subsurface concentrations in the downstream reach are ~~both 2625.5 and 25.7~~ 25.5 and 39.0 mg/kg, respectively (Tables 5.2-19 and 5.2-20).

5.2.125.2.11 Zinc in Sediment

The distribution of zinc concentrations throughout the Study Area is presented on Map 5.2-31, reported concentrations with depth are depicted on Maps 5.2-32a-o. If more than one sample was analyzed at the same surface sediment location, the greater of the two results is presented, all subsurface results are presented. Scatter plots of zinc results in the Study Area are presented on Figures 5.2-37 and 5.2-38 for surface and subsurface

sediment, respectively, segregated by the eastern nearshore, navigational channel, and western nearshore zones (Map 5.2-3335).

Summary statistics are presented in Tables 5.2-1 and 5.2-2 for surface and subsurface sediment, respectively, within the Study Area, and in Tables 5.2-3 and 5.2-4 for the eastern nearshore zone, Table 5.2-5 and 5.2-6 for the navigation channel, and Tables 5.2-7 and 5.2-8 for the western nearshore zone. Results by order of magnitude (<1, 1-10, 10-100, 100-1,000) are presented in Tables 5.2-9 for detected results only and Table 5.2-10 for combined detected and nondetect values. Finally, a histogram presenting average surface and subsurface sediment values by river mile and for the entire Study Area is in Figure 5.2-39.

Data sets for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables, the Downtown reach surface sediment results are also presented in Map 5.2-48. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12, respectively. The number of results by order of magnitude are provided in Tables 5.2-13 (detects only) and 5.2-14 (detects and nondetects). Summary statistics of results within the Downtown reach are shown in Tables 5.2-15 and 5.2-16 for surface and subsurface sediment, respectively. The number of results by order of magnitude are provided in Tables 5.2-17 (detects only) and 5.2-18 (detects and nondetects). Summary statistics of results within the Downstream reach are shown in Tables 5.2-19 and 5.2-20 for surface and subsurface sediment, respectively. The number of results by order of magnitude are provided in Tables 5.2-21 (detects only) and 5.2-22 (detects and nondetects).

5.2.12.15.2.11.1 Zinc Data Set

The zinc data set Study Area consists of 1,581 surface and 1,581 subsurface samples. 72 surface and 3 subsurface samples from the Upriver reach, 269 surface and 178 subsurface samples from the downtown reach, and 25 surface and 26 subsurface samples downstream reach.

5.2.12.25.2.11.2 Zinc in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

Zinc was reported in all 72 surface sediment samples within the Upriver reach. Concentrations reported range from 41.1 J to 165 mg/kg, with a mean of 75.2 mg/kg (Table 5.2-11) (~~Table 5.2-13~~ Four results were reported at concentrations greater than 100 mg/kg, the remaining 68 data points were between 10 and 100 mg/kg (~~Table 5.2-13~~).

Downtown Reach (RM 11.8 to 15.3)

Zinc was reported in all 269 surface sediment samples within the Downtown reach. Concentrations reported range from 3.33.27 J to 6,480 J mg/kg, with a mean of 294

mg/kg (Table 5.2-15a). The distribution of surface sediment results in the Downtown reach is presented on Map 5.2-48. The majority of results are less than 300 mg/kg, concentrations greater than 600 mg/kg were reported at RM 13 on the western shore under the Hawthorn Bridge and on the western shore between the Marquam and Ross Island bridges.

Concentrations greater than 1,000 mg/kg were reported in 15 results, 102 results were reported at concentrations between 100 to 1,000 mg/kg, 151 results were reported at concentrations between 10 and 100 mg/kg, one result was reported at a concentration less than 10 mg/kg (Table 5.2-17 and 5.2-18).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Summary statistics for the Downtown reach are presented in Table 5.2-15b excluding the Zidell data, and the Zidell data are presented in Table 5.2-15c. Zinc was reported in all 110 surface sediment samples within the Zidell action area, concentrations reported range from 3.27 J to 6,480 J mg/kg, with a mean of 555 mg/kg (Table 5.2-15c). With the Zidell facility excluded from the downtown data set, reported zinc concentrations range from 232.8 to 1,450 mg/kg, with a mean of 113 mg/kg (Table 5.2-15b).

Study Area Reach (RM 1.9 to 11.8)

Zinc was reported in all 1,581 surface sediment samples within the Study Area. Concentrations reported range from 3.73.68 J to 4,220 mg/kg, with a mean of 154 mg/kg (Table 5.2-1). The distribution of reported zinc concentrations within the Study Area is shown on Figure 5.2-37.

Concentrations greater than 300 mg/kg were reported in the eastern nearshore zone at RM 2.1E-2.3E, RM 3.7E-4.6E, RM 5.6E-5.9E, and in Swan Island Lagoon (Figure 5.2-37 and Map 5.2-29). Single exceedances greater than 300 mg/kg were reported at RM 6.7E, RM 7.2E, RM 9.9E, and RM 11.3E. The highest zinc concentration in the eastern nearshore zone of 2,050 mg/kg was reported at RM 4.6E (Station T4-UP13). Mean zinc concentrations in these areas in the eastern nearshore zone are 190 mg/kg at RM 1.9E-3E, 159 mg/kg at RM 3E-4E, 234 mg/kg at RM 4E-5E, 192 mg/kg RM 5E-6E, 123 mg/kg at RM 6E-7E, 114 mg/kg at RM 7E-8E, 227 mg/kg in Swan Island Lagoon, 97.1 mg/kg at RM 9E-10E, and 132 mg/kg at RM 11E-11.8E (Table 5.2-3).

Concentrations greater than 300 mg/kg were reported in the western nearshore zone from at RM 6.1W, RM 6.7W-6.8W, RM 8.1W-9.3W, RM 9.6W-9.7W, and RM 10.3W-10.4W (Figure 5.2-37). The maximum reported concentration of zinc in surface sediment in the Study Area of 4,220 mg/kg was detected at Station HA-43 at RM 9.2W. Mean concentrations for these areas are 150 mg/kg at RM 6W-7W, 290 mg/kg at RM 8W-9W, 394 mg/kg at RM 9W-10W, and 212 mg/kg at RM 10W-11W (Table 5.2-7). All reported concentrations of zinc in the navigation channel were less than 300 mg/kg.

Within the Study Area, zinc was reported at concentrations greater than 1,000 mg/kg in 15 results, 914 were reported at concentrations greater than 100 mg/kg, 650 results were reported at concentrations between 10 and 100 mg/kg, and two results were reported at concentrations less than 10 mg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Zinc was reported in all 25 surface sediment samples within the Downstream reach, concentrations reported ranged from 4847.6 to 188 mg/kg, with a mean of 98.2 mg/kg (Table 5.2-19). Concentrations greater than 100 mg/kg were reported in 12 results, 13 results were reported at concentrations between 10 and 100 mg/kg (Table 5.2-21).

5.2-12-35.2.11.3 Zinc in Subsurface Sediment

Upriver Reach (RM 15.3 to 26)

Zinc was analyzed in only three subsurface samples between RM 15.4 and 16 and reported at concentrations ranging from 6665.8 mg/kg to 119 mg/kg, with a mean of 8887.6 mg/kg.

Downtown Reach (RM 11.8 to 15.3)

Zinc was reported in all 178 subsurface sediment samples from within the Downtown reach. Concentrations reported ranged from 21.4 to 11,100J mg/kg, with a mean of 379 mg/kg (Table 5.2-16a). One result was reported at a concentration greater than 10,000 mg/kg, nine results were reported at concentrations between 1,000 and 10,000 mg/kg, 77 results were reported at concentrations between 100 and 1,000 mg/kg, and 91 results were reported at concentrations between 10 and 100 mg/kg (Table 5.2-17).

Summary statistics for the Downtown reach are presented in Table 5.2-16b with the Zidell data excluded, and the Zidell data are summarized in Table 5.2-16c. Zinc was reported in 30 samples within the Zidell action area at concentrations ranging from 41 to 2,270 mg/kg, with a mean of 207 mg/kg. With the Zidell data excluded from the downtown data, reported zinc concentrations in subsurface sediment range from 21.4 to 11,100J mg/kg, with a of 414 mg/kg (Table 5.2-16c),

Study Area Reach (RM 1.9 to 11.8)

Zinc was analyzed and detected in 1,581 samples within the Study Area (100 percent detection frequency) with concentrations ranging from 24.0 mg/kg to 9,000 mg/kg (Table 5.2-2) and a mean concentration of 147 mg/kg. Similar to surface sediment, zinc concentrations in the subsurface also varied within the Study Area (Figure 5.2-38; Maps 5.2-32a-o).

The subsurface sediment has elevated concentrations in generally the same areas identified in the surface sediment within the eastern nearshore zone (Figure 5.2-38). Concentrations greater than 300 mg/kg are noted at RM 2.3E, 3.7E, RM 4.2E-4.6E, RM 5.6E, RM 6.7E, in Swan Island Lagoon, RM 8.4E-8.6E, and RM 11.1E (Figure 5.2-39 and Map 5.2-32a-o). The maximum subsurface zinc concentration in the eastern nearshore zone (1,930 mg/kg) was found at Station C384 (30–128 cm bml), at the

mouth of Swan Island Lagoon. Mean zinc concentrations (Table 5.2-3) for these areas in the eastern nearshore zone are: 131 mg/kg for RM 1.9E to 3E; 149 mg/kg for RM 3E to 4E; 155 mg/kg for RM 4E to 5E; 171 mg/kg for RM 5E to 6E; 133 mg/kg for RM 6E to 7E; 291 mg/kg for RM 8E to 9E; 181 mg/kg in Swan Island Lagoon, and 159 mg/kg for RM 11E to 11.8E.

The western nearshore zone has detected zinc concentrations that exceed 300 mg/kg from RM 6.7 through 9.2 with clusters noted at RM 6.7W, RM 7.6W-7.7W, and RM 8.3W-9.2W (Figure 5.2-38 and Map 5.2-32a-o). The maximum subsurface concentration (9,000 mg/kg) was found at Station HA-42 (46-61.5-61 cm bml) at RM 8.99.1W. Mean concentrations (Table 5.2-8) for these areas in the western nearshore zone are: 126 mg/kg for RM 6W to 7W; 131 mg/kg for RM 7W to 8W; 190 mg/kg for RM 8W to 9W; and 792 mg/kg for RM 9W to 10W.

There is one peak with samples greater than 300 mg/kg in the navigation channel zone located at RM 10.2-10.3 with two individual samples exceeding 300 mg/kg at RM 6.4 and RM 7.9. The concentrations elevated within the navigation channel are near elevated concentrations the western nearshore zone. The mean concentrations for these areas are: 102 mg/kg for RM 6 to 7; 125 mg/kg for RM 7 to 8; and 127 mg/kg for RM 10 to 11 (Table 5.2-6).

Table 5.2-9 shows that there are 6 subsurface samples greater than 1,000 mg/kg and 834 samples ranging between 100 and 1,000 mg/kg. Subsurface sediment values greater than 100 mg/kg accounts for 53 percent of the detected data set. The remainder of the detected data set (741 samples; 47 percent) is between 10 and 100 mg/kg. There were no samples detected at concentrations less than 10 mg/kg.

Downstream Reach (RM 0 to 1.9)

Zinc was analyzed and detected in 26 subsurface sediment samples within the Downstream reach (detection frequency of 100 percent), with concentrations ranging from 4+10.8 mg/kg to 244 mg/kg (Table 5.2-20). Table 5.2-21 shows that approximately half of samples (14 samples) were detected at a concentration greater than 100 mg/kg and half the samples (12 samples) were detected at a concentration less than 100 mg/kg. There were no samples were detected at concentrations less than 10 mg/kg. The mean zinc concentration in this reach is 118 mg/kg.

5.2.12.45.2.11.4 Zinc Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships are examined by comparing surface and subsurface concentrations by reach and also by subareas with the Study Area reach. There is insufficient data to compare surface and subsurface concentrations in the Upriver reach. The mean zinc surface sediment concentration in this reach is 75 mg/kg (Table 5.2-11).

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The surface sediment concentrations in the downtown reach were lower than the subsurface concentrations. The mean surface concentration is 294 mg/kg, while the mean subsurface sediment concentration is 379 mg/kg (Tables 5.2-15a and 5.2-16a).

Zinc concentrations are generally similar in the surface sediments and subsurface sediments within the Study Area as a whole. The mean surface sediment concentration is 154 mg/kg and the mean subsurface sediment concentration is 147 mg/kg (Tables 5.2-1 and 5.2-2). Areas where subsurface sediment concentrations are elevated generally align with the locations where surface sediment concentrations are elevated. Figure 5.2-39 shows that mean concentrations are generally greater in the nearshore areas than in the navigation channel and the western nearshore zone has slightly greater subsurface concentrations than the eastern nearshore zone while the eastern nearshore zone has higher surface concentration.

In the eastern nearshore zone, surface sediments are slightly greater than subsurface sediment in all river mile zones except RM 6E to 9E and RM 10E to 11.8E. In the western nearshore zone, subsurface sediment concentrations are greater than surface sediment in all river miles except RM 3W to 4W, RM 6W to 7W and RM 8W to 9W. With the exception of RM8E-9E and 9W-10W the subsurface concentrations are slightly greater than the surface concentrations in these areas.

The subsurface sediment concentrations in the navigation channel are generally the same as the surface sediment concentrations, although the subsurface sediment concentrations are slightly greater in all river miles except RM 5 to 6.

The subsurface sediment concentrations in the downstream reach were greater than surface concentrations. The mean surface concentration is 98.2 mg/kg, while the mean subsurface concentration is 118 mg/kg (Tables 5.2-19 and 5.2-20).

5.2-135.2.12 Tributyltin Ion in Sediment

Several data presentations for the surface and subsurface tributyltin ion data sets for the Study Area are provided for this discussion. There are maps, scatter plots, statistical summary tables, order of magnitude tables, and a histogram of mean surface and subsurface sediment concentrations by river mile. The distribution of tributyltin ion concentrations at each surface sampling station throughout the Study Area is depicted in Map 5.2-33, concentrations with depth at subsurface stations are depicted in Maps 5.2-34a-o.

The data for tributyltin ion in the study area is presented on scatter plots on Figures 5.2-40 and 5.2-41 for surface and subsurface sediment, respectively. These plots present the data in three panels segregated by the eastern nearshore, navigation channel, and western nearshore zones (Map 5.2-33).

Summary statistics tributyltin ion within the Study Area are shown in Tables 5.2-1 and 5.2-2 for surface and subsurface sediment, respectively. Summary statistics for surface

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and subsurface sediment and are presented in Tables 5.2-3 and 5.2-4 within the eastern nearshore, Tables 5.2-5 and 5.2-6 in the navigation channel, and Tables 5.2-7 and 5.2-8 for the western nearshore zones. Tributyltin ion data is presented as orders of magnitude (e.g., <1, 1-10, 10-100, 100-1,000, etc.) in Table 5.2-9 for detected values, and Table 5.2-10 for combined detect and nondetect values. Finally a histogram presenting the average surface and subsurface sediment values for tributyltin ion by river mile and for the entire Study Area is presented in Figure 5.2-42.

Data sets for the Upriver reach, Downtown reach, and Downstream reach are only presented in statistical tables and order of magnitude tables. Additionally, surface sediment results for the Downtown reach are presented on Map 5.2-49. Summary statistics for surface and subsurface sediment within the Upriver reach are shown in Tables 5.2-11 and 5.2-12, number of results by order of magnitude are provided in Tables 5.2-13 (detects only) and 5.2-14 (detects and nondetects). Summary statistics for surface and subsurface sediment within the Downtown reach are presented in Tables 5.2-15 and 5.2-16, number of results by order of magnitude are provided in tables 5.2-17 (detects only) and 5.2-18 (detects and nondetects). Summary statistics for surface and subsurface sediment with the Downstream reach are presented in Tables 5.2-19 and 5.2-20, number of results by order of magnitude are provided in Tables 5.2-21 (detects only) and 5.2-22 (detects and nondetects).

5.2.13.15.2.12.1 Tributyltin Ion Data Set

Sampling for tributyltin ion analysis was based on a biased approach at locations near known or suspected sources. As a result, there are relatively fewer data points for these analytes in the RI sediment database than for other chemicals. This is particularly true in areas away from suspected sources, such as the navigation channel. However, areas with known or suspected tributyltin ion sources have been sufficiently characterized and the existing tributyltin ion data are sufficient for RI purposes.

The fewer number of data points for tributyltin ion limits the extent to which its distribution may be resolved, and introduces the need for caution in interpreting the surface to subsurface trends shown by the histograms (Figures 5.2-42) and in making conclusions regarding the spatial patterns of the composition of tributyltin ion in sediment (Sections 5.2.13.2 and 5.2.13.3). Within the Study Area, tributyltin ion was analyzed in 358 surface and 433 subsurface samples. The Upriver data set consists of 8 surface and 3 subsurface samples. The downtown data set is 174 surface and 65 subsurface samples, and the downstream data set is 4 surface and no subsurface samples. The small number of data points for tributyltin ion limits the extent to which its distribution may be resolved (Sections 5.2.13.2 and 5.2.13.3) and introduces the need for caution in interpreting the surface to subsurface trends shown by the histograms (Figures 5.2-42). Overall, the existing tributyltin ion data are sufficient for RI purposes.

5.2.13.25.2.12.2 Tributyltin Ion in Surface Sediment

Upriver Reach (RM 15.3 to 28.4)

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Tributyltin ion was reported in 4 of 8 surface sediment samples within the Upriver reach, concentrations reported range from 0.72 J to 2.3 µg/kg (Table 5.2-11). Three results were reported at concentrations between 1 and 10 µg/kg, and one result was reported at a concentration less than 1 µg/kg. The mean concentration in this reach is 1.31 µg/kg (Table 5.2-13).

Downtown Reach (RM 11.8 to 15.3)

Tributyltin ion was reported in 62 of 174 surface sediment samples within the Downtown reach (frequency of detection 36 percent). Concentrations ranging from 0.4 J to 1,990 µg/kg, with a concentration of 75.6 µg/kg (Table 5.2-15a). Results with the highest concentrations are located along the western shoreline (Map 5.2-49).

Tables 5.2-17 shows that there are Two results were reported at concentrations greater than 1,000 µg/kg, two between 100 and 1,000 µg/kg, 12 results were reported at concentrations between 10 and 100 µg/kg, 32 results between 1 and 10 µg/kg, and 14 results were reported at concentrations less than 1 µg/kg.

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Summary statistics for the Downtown reach excluding the Zidell data are presented in Table 5.2-15b, and summary statistics for the Zidell data excluded from the Downtown data set are presented in Table 5.2-15c. Tributyltin ion was reported in 26 of 80 surface sediment samples within the Zidell action area, concentrations reported range from 1.9 to 1,990 µg/kg, with a mean of 102 µg/kg (Table 5.2-15c). With the Zidell data excluded from the downtown data set, reported tributyltin concentrations range from 0.4 J to 1,700 J µg/kg, with a mean of 55 µg/kg (Table 5.2-15b).

Study Area Reach (RM 1.9 to 11.8)

Tributyltin ion was reported in 333 of 358 surface sediment samples within the Study Area. Concentrations reported range from 0.45J to 47,000 µg/kg with a mean of 466 µg/kg (Table 5.2-1). The distribution of reported tributyltin ion concentrations within the Study Area is presented on Figure 5.2-40 and Map 5.2-33.

Concentrations greater than 1,000 µg/kg in the eastern nearshore zone were reported at RM 3.7E, RM 7.5E, and in Swan Island Lagoon. The highest reported surface sediment concentration of 47,000 µg/kg was reported at Station SD12 (RM 3.7E, at the head of International Slip), a concentration of 46,000 µg/kg was reported at Station G421 in Swan Island Lagoon. Mean concentrations in these areas are 1,570 µg/kg at RM 3E-4E, 193 µg/kg at RM 7E-8E, and 2,340 µg/kg in Swan Island Lagoon (Table 5.2-3).

Within the navigation channel, tributyltin ion concentrations greater than 1,000 µg/kg were reported near Swan Island Lagoon (1,800 µg/kg at Station SD124 at RM 7.7, Figure 5.2-40). The mean concentration at RM 7-8 in this areas is 373 µg/kg (Table 5.2-5).

A single measurement greater than 1,000 µg/kg was reported at RM 8.W8 in the western nearshore zone, the mean concentration at RM 8W-9W is 8483.8 µg/kg (Table 5.2-7).

Two results were reported at concentrations greater than 10,000 µg/kg, 12 results were between 1,000 and 10,000 µg/kg, 71 results were reported at concentrations between 100 and 1,000 µg/kg, 125 results were between 10 to 100 µg/kg, 108 results between 1 and 10 µg/kg, and 15 results were reported at concentrations less than 1 µg/kg (Tables 5.2-9, Map 5.2-33).

Downstream Reach (RM 0 to 1.9)

Tributyltin ion was reported in all 4 samples within the Downstream reach at concentrations between from 0.37 J and 1.2 J µg/kg, with a mean of 0.85 µg/kg (Tables 5.2-19, 5.2-21 and 5.2-22).

5.2.13.35.2.12.3 Tributyltin Ion in Subsurface Sediment

Upriver Reach (RM 15.3 to 28.4)

Tributyltin ion was analyzed in three subsurface sediment samples between RM 15.4 and 16, and was not detected at maximum detection limit of 0.094 µg/kg.

Downtown Reach (RM 11.8 to 15.3)

Tributyltin ion was reported in 21 of 65 subsurface sediment samples within the Downtown reach, concentrations reported range from 0.55 J µg/kg to 14,000 µg/kg (Table 5.2-15a) and a mean concentration of 1,052 µg/kg.

One result was reported at a concentration greater than 10,000 µg/kg, one each was reported between 1,000 and 10,000 µg/kg and between 100 and 1,000 µg/kg, five results were between 10 and 100 µg/kg, nine were between 1 and 10 µg/kg, and four results were reported at a concentration less than 1 µg/kg (Tables 5.2-17).

In 2011, a remedial action was taken at the Zidell facility under ODEQ authority. Summary statistics for the Downtown reach with the Zidell data excluded are presented in Table 5.2-16b, and summary statistics for the Zidell data are presented in Table 5.2-16c. Tributyltin ion was reported in 13 of 23 subsurface sediment samples within the Zidell action area, concentrations reported range to a maximum reported value of 14,000 µg/kg, with a mean of 1,697 µg/kg. When the data from the Zidell facility are excluded from the downtown data set, the range of reported concentrations ranges from 0.55 J to 23 µg/kg, with a mean of 4.54.48 µg/kg (Table 5.2-16c).

Study Area Reach (RM 1.9 to 11.8)

Tributyltin ion was detected in 223 of the 433 subsurface samples analyzed within the Study Area. Concentrations reported range from 0.32J to 90,000 µg/kg, with a mean of

1,410 µg/kg (Table 5.2-2). Tributyltin ion concentrations in subsurface sediment within the Study Area are presented on Figure 5.2-41 and Maps 5.2-34a-o.

Tributyltin ion concentrations reported at concentrations greater than 1,000 µg/kg are present at RM 7E-8E and in Swan Island Lagoon (Figure 5.2-41). A single result of-at 1,000 µg/kg was reported at RM 5.6E. Mean concentration in these areas is 196 µg/kg at RM 5E-6E, 1,250 µg/kg at RM 7E-8E, 13,700 µg/kg at RM 8E-9E, and 5,380 µg/kg in Swan Island Lagoon (Table 5.2-4).

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Within the western nearshore zone there were no reported tributyltin ion concentrations greater than 1,000 µg/kg (Figure 5.2-41). Concentrations greater than 1,000 µg/kg were reported in the navigation channel at RM 7.8 and in Swan Island (Maps 5.2-34a-o). The highest reported concentrations the subsurface sediment are generally found at the same surface locations where tributyltin ion concentrations are greater than 1,000 µg/kg along the eastern nearshore zone (Maps 5.2-34a-o).

Within the Study Area, eight results greater than 10,000 µg/kg, 14 are between 1,000 and 10,000 µg/kg, 35 results were reported at concentrations between 100 and 1,000 µg/kg, 88 results were between 10 and 100 µg/kg, 62 were between 1 and 10 µg/kg, and 16 results were reported at concentrations less than 1 µg/kg (Table 5.2-9).

Downstream Reach (RM 0 to 1.9)

Tributyltin ion was not analyzed in subsurface sediment samples within the Downstream reach.

5.2.13.4.5.2.12.4 Tributyltin Ion Surface and Subsurface Sediment Relationships

Surface and subsurface sediment relationships were examined by comparing surface and subsurface concentrations by reach and also by subareas within the Study Area. There are insufficient data to compare surface and subsurface concentrations in the Upriver and Downstream reaches.

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Within the downtown reach, the mean tributyltin ion concentrations are ~~7574.6~~ and 1,052 µg/kg in surface and subsurface sediment, respectively. With the Zidell data excluded, this relationship is reversed, and the mean concentrations in surface and subsurface sediment are 55.0 and ~~4.54.48~~ µg/kg, respectively.

Within the Study Area, tributyltin ion concentrations are generally greater in the subsurface than in surface sediments, the mean concentrations are 466 and 1,410 µg/kg in surface and subsurface sediment, respectively. Most areas throughout the Study Area reach lack a strong or consistent vertical concentration gradient, although the majority of the contamination appears in the shallower ~~near-subsurface~~ samples. This pattern is supported by Maps 5.2-34d-j.

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